Griffon Helicopter Neck Strain Project:

Part 1: Mission Function Task Analysis and Physical Demands Analysis Report.

Part 2: Physical Demands Analysis Library

Prepared by:

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Abstract

This project undertook a Mission Function Task Analysis (MFTA) and Physical Demands Analysis (PDA) of the Griffon Helicopter aircrew (pilots and flight engineers) with a focus on mitigating aircrew neck strain/pain. Neck pain, particularly when wearing Night Vision Goggles (NVGs) is frequently reported by Griffon Helicopter Aircrew (Pilots and Flight Engineers). Mechanisms and risk factors for acute and chronic neck injury in aviation aircrew are well documented in the literature, however, there is limited information available about the prevalence and magnitude of the physical demands associated with these acute and chronic injury risk factors for the dynamic performance of aircrew tasks during complete mission durations.

This study developed a library of mission tasks comprised of associated postural sequences for each of the Flying Pilot, Non-flying Pilot, and Fight Engineer roles. This task library comprised the building blocks to enable the development of any number of possible customized Griffon mission types and characteristics. Based on the identified postural sequences from this library of mission tasks, aircrew underwent motion capture data collection by simulating the postural sequences for both day and night missions. These data were then analyzed for postural range of motion and forces on the neck to derive a Physical Demands Analysis for each of these postural sequences. Two mission examples were built for this study: a logistics support and surveillance mission (5.5 hour mission) and a slung load training mission (2.5 hour mission). Cumulative physical demands were then derived for all aircrew roles in both missions for both day and night conditions.

Compression, resultant torque, and posterior shear were found to best represent the physical demands affecting neck strain among Griffon aircrew. Generally, pilots experienced more compression than torque or shear due to their predominantly upright, seated posture with their head in a level plane. Flight engineers mostly experienced more resultant torque and posterior shear due to the greater preponderance of flexed neck postures involved in their tasks. Cumulative physical demands analyses of both example missions (Logistics Support and Surveillance Mission and Scan Load Training Mission), demonstrated that night missions were generally more demanding than day missions. Pilots experienced a somewhat larger cumulative load for compression while flight engineers typically experienced the largest cumulative load for resultant torque, tension, and shear for both day and night conditions.

The findings of this study are summarized and a new, Integrated MFTA / PDA process model (IMPM) is introduced. Ways and means to employ the IMPM model to evaluate possible neck strain solutions are described and discussed. A number of administrative and engineering options to reduce neck strain are proposed and supported with IMPM modeling examples. Finally, areas for future work to expand and improve on the work to date are suggested.

Résume

French translation of Abstract, provided by DRDC

Executive Summary

Griffon Helicopter Neck Strain Project: Part 1: Mission Function Task Analysis and Physical Demands Analysis Report

David W. Tack, Jordan Bray-Miners, Edward T. Nakaza, Alex Osborne, Brian Mangan. Human*Systems*® Incorporated; DRDC No. CR2014-XXX; Defence R&D Canada – Toronto Research Centre; May, 2014.

Aim This project undertook a Mission Function Task Analysis (MFTA) and Physical Demands Analysis (PDA) of the Griffon Helicopter aircrew (pilots and flight engineers) with a focus on mitigating aircrew neck strain/pain. A secondary aim was to inform a subsequent Head Supported Mass (HSM) study and options analysis for a test bed, and opportunities for changes in Tactics Techniques and Procedures.

Background Neck pain, particularly when wearing Night Vision Goggles (NVGs) is frequently reported by Griffon Helicopter Aircrew (Pilots and Flight Engineers). In a few cases the problem is so severe that the crewmember is no longer able to fly (grounded). Mechanisms and risk factors for acute and chronic neck injury in aviation aircrew are well documented in the literature. However, there is limited information available about the prevalence and magnitude of the physical demands associated with these acute and chronic injury risk factors for the dynamic performance of aircrew tasks and postural sequences and relating these demands to the cumulative exposure associated with a range of possible complete mission durations.

By measuring the real-time dynamic physical demands associated with the complete range of aircrew tasks for all roles, day and night, it would be possible to identify problematic tasks, postures, or discrete elements in a postural sequence so that engineering design interventions and amelioration methods could be better targeted and prioritized. Relating these physical demands to the tasks and activities performed throughout complete missions, on a moment by moment basis, it would be possible to determine the cumulative demands associated with different missions, aircrew roles, and in day or night conditions and provide insights into administrative methods (e.g. work sharing, work/rest scheduling) to reduce the overall neck strain load on aircrew.

Methods This study began by investigating and updating a pre-existing 1997 Griffon MFTA to match 2013 operations with the help of pilots and flight engineers from 400 Tactical Helicopter Squadron. This updated MFTA was then deconstructed into a library of mission tasks comprised of associated postural sequences for each of the Flying Pilot, Non-flying Pilot, and Fight Engineer roles. This task library comprised the building blocks to enable the development of any number of possible customized Griffon mission types and characteristics. Based on the identified postural sequences from this library of mission tasks, six pilots and seven flight engineers underwent motion capture data collection by simulating the postural sequences for both day and night missions for each of the 12 Flying Pilot, 12 Non-flying Pilot, and 22 Flight Engineer postural sequences. These data were then analyzed for postural range of motion and forces on the neck to derive a Physical Demands Analysis for each of these postural sequences. The results of these analyses were then input into the mission-builder model to generate cumulative mission demands for neck strain in each aircrew role. Two mission examples were built for this study: a logistics support and surveillance mission (5.5 hour

mission) and a slung load training mission (2.5 hour mission). Cumulative physical demands were then derived for all aircrew roles in both missions for both day and night conditions.

Results PDA results are detailed for range of motion, forces, and moments for all postural sequences employed in mission tasks by all three aircrew roles. High physical demand postural sequences are identified for each role and range of motion results are related to defined postural comfort zones. Flight engineers evidenced highest postural angles in flexion and right axial rotation, owing to visual scanning tasks outside the aircraft, typically below and towards the back of the aircraft (i.e. tail rotor). Both the flying and non-flying pilots evidenced flexion and left/right axial rotation due to outside scanning tasks. Non-flying pilots, in the surveillance mission investigated, also engaged in prolonged neck flexion required to view the MX-15, the CDU, maps, and reference materials. For all aircrew, postural angles were more severe when wearing NVGs due to the increased scanning range required with the narrow field of view of the goggles.

Compression, resultant torque, and posterior shear were found to best represent the physical demands affecting neck strain. Generally, pilots experienced more compression than torque or shear due to their predominantly upright, seated posture with their head in a level plane. Flight engineers mostly experienced more resultant torque and posterior shear due to the greater preponderance of flexed neck postures involved in their tasks. Similarly, non-flying pilots evidenced high resultant torque and posterior shear when performing prolonged neck flexion when viewing the MX-15, CDU, and maps.

Cumulative physical demands analyses of both example missions (Logistics Support and Surveillance Mission and Scan Load Training Mission), demonstrated that night missions were generally more demanding than day missions. Pilots experienced a somewhat larger cumulative load for compression while flight engineers typically experienced the largest cumulative load for resultant torque, tension, and shear for both day and night conditions. Comparing the normalized dose rate between the two missions, the FE evidenced significantly higher dose rates than pilots. As well, FEs experienced noticeably higher posterior shear (140%) and resultant torque (120%) demands during the training mission example as compared to the operations mission example, while there was little difference for the pilots. This reinforces the perception by FEs that training missions may be more demanding on the neck than operational missions.

Discussion The findings of this study are summarized and a new, Integrated MFTA / PDA process model (IMPM) is introduced. Ways and means to employ the IMPM model to evaluate possible neck strain solutions are described and discussed. A number of administrative and engineering options to reduce neck strain are proposed and supported with IMPM modeling examples. Finally, areas for future work to expand and improve on the work to date are suggested.

Sommaire

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1. Background

Neck pain, is frequently reported by Griffon Helicopter Aircrew (both pilots and flight engineers), particularly when wearing Night Vision Goggles (Adam, 2004, Neary et al., 2010) and the implementation of the Heads-Up Display (HUD) has exacerbated this problem. In some cases the situation can become so severe that aircrew are grounded and no longer able to fly. This concern is not unique to Canada, nor limited to only rotary wing aircraft such as the CH-146 Griffon Helicopter. In fact, it is an international problem that militaries have been trying to resolve for well over a decade. Finding a solution to this problem is a high priority for 1 Canadian Air Division (CAD), 1 Wing, Surgeon General, DGSTAN, Director of Air Requirements (DAR 9), Director Air Programs, as well as the Griffon pilots and flight engineers.

Considerable research has been conducted in the area of Aircrew Neck Strain, and a recent systematic literature review (articles from 2003 through 2013) resulted in several thousand articles of which 228 unique articles and 79 standards or recommendations were down-selected (McLaughlin, 2013). These references addressed both acute and chronic injuries according to the following seven areas; General Causes and Reduction of Neck Strain, Posture, Force and Torque Profiles, Mass Properties, Psychophysical Factors, Physiological Factors, and Standards.

With respect to acute injury, it is typically characterized by the sudden onset of high acceleration forces, impact, extreme neck angles or a combination thereof. Numerous investigations on helmet and ± high gravity environments have been carried out:

- +Gz studies = (Freivalds and McCauley 1990; Lee, Freivalds and Lee 1991; Perry, Buhrman and Knox 1993; Buhrman and Perry 1994; Shender, Paskoff, Askew et al. 2001; Eveland 2002; McEntire, Alem and Brozoski 2004);
- +Gx studies = (Mertz and Patrick 1971; Muzzy, Bittner and Willems 1986; Ashrafiuon, Alem and McEntire 1998; Mobasher, Brozoski, McEntire et al. 1998)

The United States Air Force has even developed an interim head/neck criteria on maximum head supported weight and altered centre of mass (CoM) for helicopter aircrew helmets to mitigate the risk of neck injury for a 35 G acceleration environment with a dynamic overshoot ratio of 1.5 (McEntire, Shanahan, 1998). This suggests a maximum allowable helmet mass is 2.5 kg depending on the location of the helmet CoM. With respect to chronic injury, neck pain is assumed to be a multifactorial disease (Ariens, van Mechelen, Bongers, Bouter, van der Wal, 2000; Cote et al., 1998, Croft et al., 2001, and Green, 2003 as cited by Forde, Albert, Harrison, Neary, Croll, Callaghan, 2011). Many risk factors can be attributed to chronic injury including physical, psychosocial, and individual risk factors (Ariens, van Mechelen, Bongers, Bouter, van der Wal, 2000), and theories of musculoskeletal injury causation include multivariate interaction, differential fatigue, cumulative load and over exertion (Kumar, 2001).

In order to better understand the Griffon aircrew exposure to acute and chronic injury risk factors, and to determine how best to prioritize risk mitigation efforts, one must first understand the missions, functions, tasks and postural sequences required in the job and their associated physical demands. Although studies have investigated measures of aircrew neck pain/strain for a typical mission subset (e.g. Forde et al., 2011), we are unaware of any study that has systematically captured the complete second-by-second pattern and profile of musculo-skeletal neck strain measures for all crewmembers over the course of a wide range of possible full missions.

An initial research plan was undertaken to develop the most effective methodology and approach to developing an MFTA that enables the creation of customizable, composite missions, PDAs of associated mission tasks, and measures of cumulative demand over the course of entire missions (Tack and Nakaza, 2013). This project represents the execution of that plan.

2. Aims

The aim of this project was to perform a Mission Function Task Analysis (MFTA) and Physical Demands Analysis (PDA) of the Griffon Helicopter aircrew (pilots and flight engineers) with a focus on mitigating aircrew neck strain/pain.

Secondary aims included:

a) Verify and update the original 1997 Griffon MFTA.

b) Create the capability to generate customized composite missions based on MFTA task sequences to be able to evaluate mission differences in neck strain.

c) Identify activity-specific physical demands associated with neck strain for each aircrew role (i.e. Flying Pilot, Non-flying Pilot, and Flight Engineer) for the range of MFTA tasks.

d) Identify levels of cumulative physical demands for neck strain for a given mission(s).

e) Develop a capability to leverage the results of this project to enable the Directorate of Technical Airworthiness and Engineering Support (DTAES) to evaluate future procurement options, modifications to the cockpit/cabin workspaces, and equipment modifications.

3. Methods

The methods and techniques employed in the MFTA and the PDA analyses are described in this section.

For the development of the MFTA, focused interviews were held with Pilot/FE teams to review the MFTA mission tasks, expand the information content on each task hierarchy, as well as to describe and derive the associated postural sequences involved in each task. As mission components were identified they were added to the Mission Task Library as were the postural sequences specific to each crew position.

The PDA data collection for each of these postural sequences in the Mission Task Library was then captured concurrently using the Xsens motion capture system. Once the MFTA descriptions were complete, and the postural sequence libraries populated, all efforts were focused on PDA data collection of these libraries by role, including individual differences, until a sufficient representative sample of pilots and FEs were collected. The following section describes the method that was adopted for the MFTA and PDA in more detail.

3.1 Mission Function Task Analysis (MFTA)

The Mission Function Task Analysis (MFTA) development process was based on a 1997 Griffon Helicopter MFTA (Canadian Marconi Company, 1997) which was initially verified by 1 Wing in September 2013. Following this initial review, approximately 1,500 tasks were further reviewed by members of the 400 Tactical Helicopter Squadron, and evaluated for accuracy of information as it pertained to 2013 operations. The general consensus was that the 1997 MFTA provided a good framework but many of the task items were tactically or procedurally out of date, tasks are no longer carried out as outlined, tasks were too detailed, not detailed enough, or a combination of the above. Essentially, much has changed in 14 years as a result of the Afghanistan experience and the 1997 MFTA no longer reflected current tactics, techniques, or procedures. For example, several missions and tasks in the 1997 MFTA include hovering for reconnaissance and surveillance, and nap-of-the-earth flight during transitions, and these are no longer performed by Griffon crews and other new flying maneuvers have been introduced to perform these functions. Griffon aircrew were unanimous in stating 'he who hovers dies'. New technologies (e.g. MX-15 multi-sensor imaging and lasing pod) have significantly changes the ways and means Griffon crews perform surveillance and overwatch tasks.

Therefore, over the course of 18 days between December 2013 through March 2014, 15 SMEs (9 Pilots and 6 Flight Engineers) from the 400 Tactical Helicopter Squadron at Canadian Forces Base Borden, participated in re-building and updating the MFTA task content, expanding the information content on each task hierarchy, and deriving the associated postural sequences involved in each task. Focused interviews were held with Pilot/FE teams and lead by two personnel from HSI®. The 1997 MFTA was effectively decomposed into constituent tasks and sub-tasks that reflected the common building blocks of any mission.

The nine Pilots consisted of two individuals holding the rank of Major, and seven holding the rank of Captain. The six Flight Engineers consisted of one Sergeant, two Master Corporals and three Corporals (Table 1).

Table 1: MFTA Pilot and Flight Engineer Subject Matter Experts

Rank	No.
Major	2
Captain	7
Sergeant	1
Master Corporal	2
Corporal	3
N =	**15**

During the focused interviews the following information was elicited from the SMEs using elicitation probes, questions and interview techniques:

- Mission components
- Detailed task descriptions (i.e. this is the description of what we do)
- Detailed postural sequences (i.e. this is a description of the posture that we adopt in carrying out this task)
- Demonstrated postural sequences utilizing the actual Griffon Helicopter airframe located adjacent to the interview setup (i.e. this is the adopted posture and movement sequence as described above) (Reference Figure 1)
- Timings (i.e. this is how long this task and postural sequence takes),
- Frequency (i.e. this is how often this task/postural sequence is carried out)
- Effect of night flying

Figure 1: MFTA Focused Interview Setup

As mission components were identified they were added to the Mission Task Library as were the postural sequences specific to each crew position; Flying Pilot (FP), Non-Flying Pilot (NFP) and Flight Engineer (FE).

3.2 Physical Demands Analysis (PDA)

3.2.1 PDA Data Collection

The PDA data collection effort took place in parallel with the MFTA development. Data were collected from 13 participants from 27 January until 25 February 2014, at 400 Squadron, located at CFB Borden. Of the 13 PDA participants, 6 were Flight Engineers (all male) and 7 were Pilots (1 female, 6 male). Each participant completed six hours of PDA data collection. The session consisted of a short in-brief, followed by the collection of personal information and anthropometric measures. Afterwards, participants were required to complete their respective postural sequences (26 for Flight Engineers; 12 for Pilots as Flying Pilot, and 12 for Pilots as Non-Flying Pilot), as identified by the MFTA process, in both day and night conditions.

3.2.1.1 Anthropometry and Personal Information

The beginning of each data collection session started with a short in-brief, followed by the collection of personal information and anthropometric measures. The following personal information was collected:

- name,
- gender,
- role,
- rank,

- years of experience,
- years with griffon mission experience, and
- if they use the helmet counter weight.

The following anthropometric measures were collected:

- stature,
- ankle height,
- knee height,
- hip height,
- hip width,
- shoulder width,
- arm span,
- shoe size, and
- shoe sole thickness.

3.2.1.2 Postural sequences

Twenty-six (26) Flight Engineer postural sequences were identified during the MFTA portion of the project as described in section 3.1. Four tactical postural sequences were not collected at 400 Squadron as they did not have sufficient experience in these tasks (e.g., door gunning, rappelling). Therefore, 22 Flight Engineer postural sequences were collected for all FEs in both day and night operations. Additionally, twenty-four (24) postural sequences were developed for Pilots, 12 for the Flying Pilot and 12 for the Non-Flying Pilot.

Prior to data collection each postural sequence was explained to the participant, with an emphasis on the general goal or purpose behind each posture. It was crucial that only the goal or purpose of the posture was described and that the sequence itself was not described to ensure that we captured each individual's unique method or technique for completing each postural sequence. Xsens motion capture and HD video files were collected simultaneously as the participant completed each postural sequence. These processes are described in more detail below.

3.2.1.2.1 Xsens Motion Capture

Xsens motion capture files were collected using the Xsens MVN Biomech system. This system comprises 17 sensor inertial measurement devices that provide kinematic data for 23 body segments and 22 joints. Participants either wore a Lycra suit, or adjustable straps, to situate, align, and contain the 17 inertial sensors. If the Lycra suit was worn, Figure 2, all flight equipment was worn over top. If the straps were worn, Figure 3, then the flight suit was worn underneath the straps and their flight vest was worn over the straps and sensors. In both cases the head sensor was attached to the outside of the helmet using Velcro.

Figure 2: Example of participant wearing Xsens MVN Biomech Lycra suit.

Figure 3: Example of participant wearing Xsens MVN Biomech strap suit.

Data from the MVN Biomech suit was collected using MVN Studio Pro 3.3 software. The MVN Biomech reference camera was employed for all the data collection session, in order to provide a "live" synchronized video reference of the motion being collected. Figure 4 is a screen capture of MVN Studio Pro software. The following suit configuration was used for each participant:

- sample rate, 120 Hz;
- suit configuration, Full Body;
- scenario, pelvis Fixed; and

- fusion engine mode, XKF3.

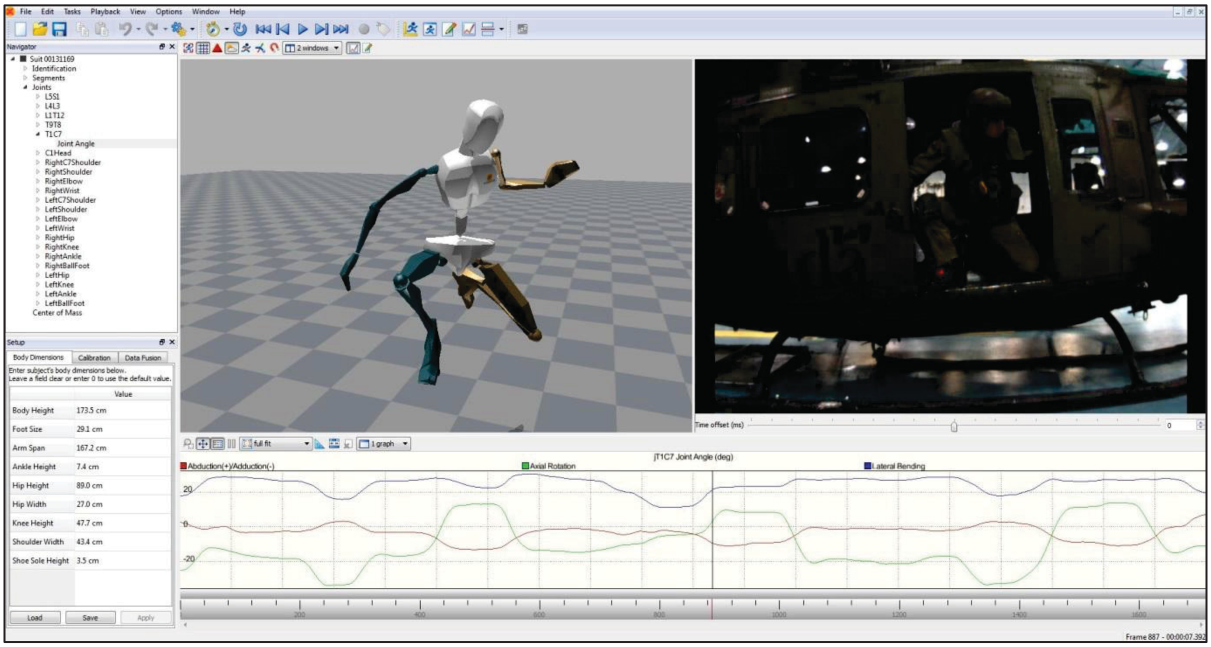

Figure 4: MVN Studio Pro Screen Capture

To initiate a recording, the Xsens operator would countdown aloud so that the start of the data file was synchronized with the start of the postural sequence motion. When the participant finished carrying out the posture motions, they were instructed to say "done/OK", to synchronize the end of the postural sequence with the end of the data file. This method ensured that irrelevant preceding or following data, or motion, would not be included in the PDA analysis.

3.2.1.2.2 HD Video

Additional HD video was recorded to provide a higher quality "live" reference of all the collected motion files. It was not synchronized with the Xsens motion capture directly and was primarily intended for post hoc visual reference of each postural sequence. The HD Video also provided a high-quality video back-up that could be used for 2D video motion analysis if problems arose with the Xsens motion capture methodology, however, this back-up was not required.

3.2.2 PDA Data Analysis

The primary focus of the PDA was analyzing the motion capture files collecting using the Xsens MVN Biomech system. Video files were used to supplement the motion tracking files to provide a video representation of what motions were captured during the entire PDA data collection effort.

The PDA data analysis steps were:

i) quality screening and clipping of Xsens files;

ii) importing Xsens files into Visual3D and export raw data;

iii) importing raw data into Matlab processor and export results;
iv) summarizing results in Excel and generating PDA workbooks.

Each step will be explained in more detail in the following sections.

3.2.2.1 Quality Screening and Clipping Xsens Files

The initial step in processing the motion capture files was to review them for quality and clip out any undesired movement that occurred at the beginning and end of each trial. This would include head movement that was not relative to the postural sequence itself (e.g., looking at the camera after completion of the dictated motion), and duplicated iterations of the desired motion (e.g., getting up from a seated position to conduct equipment handling in the cabin twice in a row.). For additional quality control, only files that had head drift of less than 10° were included in the analysis.

Once all of the data files were reviewed for quality and clipped as necessary, they were exported as C3D files to be imported into C-Motion, Visual3D software.

3.2.2.2 Visual3D Processing

Visual3D was used to apply a user developed model to a "signal" file (Xsens C3D files) and export x, y and z joint angles, moment, and forces at the C7 joint.

3.2.2.2.1 Creating Model Files

Limitations with the software required the model to simplify the head and neck as one single segment with a proximal joint at C7/T1 and distal reference point offset from the midpoint between left and right auricularis reference points. To correlate with Xsens joint angle output, the Visual3D model head axis system was

x, positive forward;

y, positive upward; and

z, positive to the right.

A model file was created for each of our five helmet conditions: 1) helmet only; 2) helmet and NVGs (down); 3) helmet, NVGs (down) and counter weight; 4) helmet and NVGs (up); and 5) helmet, NVGs (up) and counterweight. The respective model files represented each helmet condition by defining a head segment with parameters that corresponded to the condition center of mass (COM) location and mass moments of inertia. Properties used for each helmet condition are presented in Table 2. All centre of mass and mass moment of inertia values were analytically derived using the following assumptions:

i) C7-Tragion length is 11.1 cm (Gordon et al., 2013);
ii) Head COM from tragion is 1 cm in x-axis, and 2.5 cm in y-axis (Nakaza, 2007);
iii) head mass is 4.54 kg; and
iv) tragion is in the middle of the helmet earpiece.

Table 2: Head and Helmet Condition Mass Properties

Condition	Mass (kg)	Center of Mass – from C7 (cm)			Mass Moment of Inertia (kg·cm^2)		
		x	y	z	x	y	z
Head & Helmet	6.06	0.96	13.69	0.00	349.52	310.65	365.18
Head & Helmet with NVG (down)	7.00	2.68	13.47	0.00	369.91	613.14	673.02
Head & Helmet with NVG (down) & counterweight	7.90	0.58	13.76	0.00	396.33	902.02	960.98
Head & Helmet with NVG (up)	7.00	2.71	14.64	0.00	382.07	688.22	772.42
Head & Helmet with NVG (up) & counterweight	7.90	0.61	14.79	0.00	403.78	1020.08	1098.67

3.2.2.2.2 Creating Pipeline

Pipelines are used within Visual3D to automate the analysis process. A pipeline allows for multiple C3D files to be evaluated using identical data processing steps.

3.2.2.2.3 Output

The output generated from Visual3D was a tab delimited text file that contained x, y and z joint angles, moments and forces at the neck joint, relative to the torso coordinate system.

3.2.2.3 MATLAB Processes

Text files exported from Visual3D were filtered using a MATLAB designed 4th order, dual pass Butterworth filter with a cut-off frequency of 10 Hz. Filtered files were exported to Microsoft Excel format.

3.2.2.3.1 Filter Design

MATLAB functions "butter()" and "filtfilt()" were used to design the Butterworth filter and apply it to the Visual 3D output file. To determine the appropriate cut-off frequency to use with the Butterworth filter, a residual analysis was conducted. Equation 1 below was used to calculate the residual value for output filtered at 1, 3, 6, 10, 15, 20, 25, and 30 Hz., where y is the raw data value, y' is the filtered value for N data points.

$$R = \sqrt{\frac{\sum_{i=1}^{N}\left(y_i - y'_{i\,i}\right)^2}{N}} \qquad \text{Equation 1}$$

The results of the residual analysis are shown in Table 3.

Table 3: Residual Analysis Results

Cutoff Frequency	Residual Error
1	2.34
3	2.18
6	1.83
10	1.40
15	1.24
20	1.16
25	1.10
30	1.07

The graphical results of the residual analysis are shown in Figure 5. To determine the appropriate cut-off frequency for the remainder of the PDA analysis, the linear portion of the curve was extrapolated back to the y-intercept, which was found to be 1.4. From Table 3, a residual error of 1.4 was found at 10 Hz and therefore, 10 Hz was chosen as the cut-off frequency for the Butterworth filter.

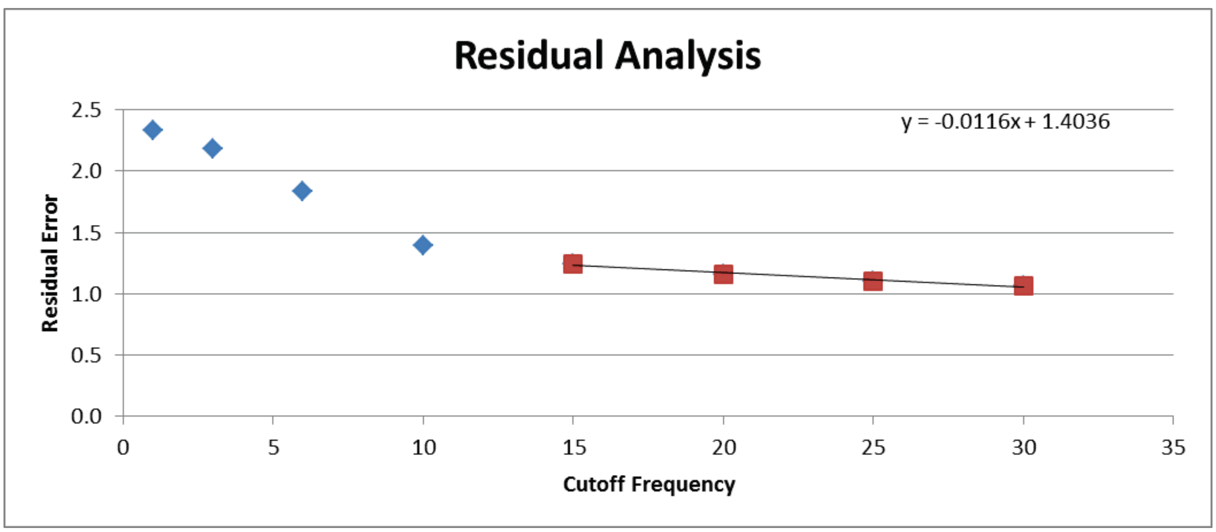

Figure 5: Residual Analysis of Sample Data

3.2.2.4 Excel Results

A PDA workbook was created for each postural sequence. Within each workbook there is a master PDA sheet, a range of motion (ROM) sheet, and each participant's PDA worksheets.

3.2.2.4.1 Participant PDA Worksheets

A separate worksheet was generated for both day and night operations for each participant within the PDA workbook. The individual participant PDA sheets provide information about the participant, text description of the postural sequence, and equipment used during data collection. The following data profiles were graphed in both day and night conditions:

- 3D joint angles,
- resultant neck torque, and
- 3D joint forces.

The following 3D force and moment results were calculated for both day and night conditions were:

- peak,
- average, and
- area under the curve.

The following 3D joint angle results were calculated for both day and night conditions were

- peak, and
- average.

3.2.2.4.2 Master PDA Worksheet

The master PDA sheet summarizes the results from all the individual participant PDA sheets. The 3D force and moment results calculated on the master PDA were:

- average of the participant's peaks,
- overall average, and
- average of the participant's area under the curve.

The 3D joint angle results calculated on the master PDA were

- average of the participant's peaks, and
- overall average.

The master PDA worksheet was used to populate the Mission Builder as described in section 4.3.

3.2.2.4.3 ROM Worksheet

The Range of Motion (ROM) worksheet summarizes a ROM analysis for each participant as well as the average across all the participants who completed the postural sequence. Table 4 shows the defined zones that were used to characterize flexion/extension, left/right axial rotation, and left/right lateral bending. The main zones for each of the three joint movements were based on Forde et al. (2011). Additional zones were created to extend the investigation of potential injury sources, these zones were based on Anderson et al. (2003), Eklund, Odenrick, Zettergren, and Jahansson (1994), and Henry Dreyfuss Associates (2002).

Table 4: ROM Analysis Zones

Reference Source	Flexion/Extension	Category
Forde et al. (2011)	>10	Extension
	10 to -10	Neutral
	-10 to -30	Mild
	<-30	Severe
Anderson et al. (2003)	<-20	
Eklund et al. (1994)	<-15	
	Rotation	
Forde et al. (2011)	<10	Neutral
	10 to 40	Mild
	>40	Severe
Eklund et al. (1994)	>15	
	>45	
	Lat. Bend	
Forde et al. (2011)	<15	Neutral
	15 to 30	Mild
	>30	Severe
Henry Dreyfuss Associates (2002)	<20	
	20 to 54	
	>54	

Figure 6 shows a visual representation of the defined comfort zones used by Forde et al. (2011). In reference to potential injury criteria, Anderson et al. (2003) derived a threshold criteria where if more that 66.67% of time was spent flexed over 20° then your odds of injury increased by a factor of 2.26. Furthermore, Eklund et al. (1994) outline injury threshhold if:

- 80% of time is flexed over 15°,
- 80% of time is rotated over 15°, and
- 50% of time is rotated over 45°.

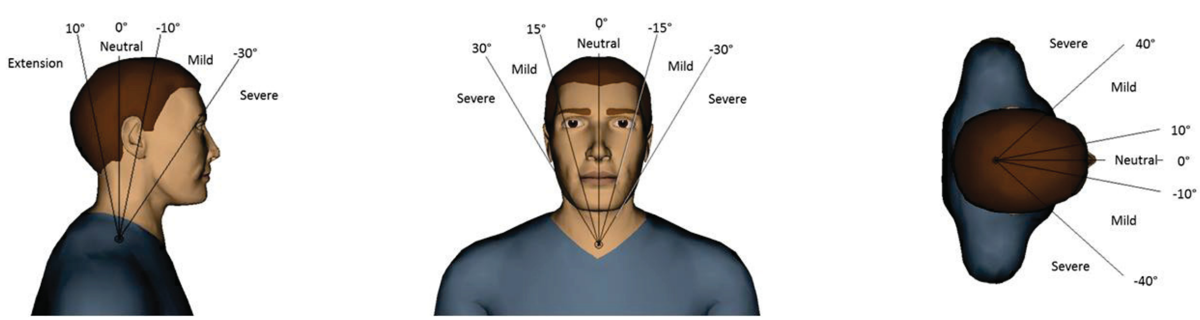

Figure 6: Forde et al. (2011) Defined Posture Zones

4. Results

Based on the review of the original 1997 MFTA, 15 Griffon Helicopter SMEs expanded and consolidated the information content on each task hierarchy including mission components, detailed descriptions, postural sequences, timings, and frequency and this information was catalogued into the Mission Task Library. The information from the Mission Task Library was then systematically grouped into logically occurring task blocks as a function of mission phase requirements to create the Mission Builder tool. Each of the postural sequences within the Mission Task Library was captured using a digital motion capture system (Xsens) and catalogued into the PDA Library which was integrated into a relational database. The following section describes these results of both the MFTA and the PDA analyses in more detail.

4.1 MFTA

The MFTA Task Library (shown in Annex A) and the concept of the Mission Builder tool are described below.

4.1.1 Mission Task Library

A total of 21 mission blocks (Table 5), 95 unique mission tasks (Table 6), and 69 unique mission sub tasks (Table 7) were defined and catalogued into the Mission Task Library.

Table 5: MFTA Mission Blocks

Pre-flight	Loiter Profile	Combat Attack
Taxi	Landing	Combat Attack (Door Guns)
Taxi (Airport)	Pick-Ups	React Missile
Take-off	Drop-Offs	React Gunfire
Transition	Checks	React Fighter Attack
Nav/Comms	Recce	Shutdown
Transit	Observation Maneuver	Re-Tasking

Table 6: MFTA Mission Tasks

Load Mission Kit	Zoom Climb (6000')	SAR Hoist Stokes Litter
Mission Kit Check (Hook)	Climb with Slung Load	SAR Hoist SAR Tech
Open and Ingress AC	Route Planning	Slung Loads Drop (Pilot)
Start-up/Last Chance Insp.	En-route Navigation	Slung Load Landing
Post-start Checks	Set up Comms for Re-bro	Slung Load Unhook Manual
Pre-taxi Checks	Conduct Re-bro in Loiter	SAR Hoist Billy Pugh
Taxi Field	Transit Regular VFR	Rappelling Troops
Pre-Takeoff Checks	Transit Regular IFR	2-Full Check FE
Take-off to Hover Regular	Transit Contour	2-Full Check NFP Pilot
Post-Take off Checks	Transit NOE	SAR Check
Taxi to Hold Area	Transit with Slung Load	Plan ISR
Land at Hold Area	Race Track or Circular	Conduct ISR Profile
Obtain IFR Clearance	Loiter Figure 8	Plan Observation Maneuver
Pre-departure Checks	Loiter Dog Bone	Execute Obs Maneuver
Take-off No Hover Regular	Review Terminal Navigation	Assess/Record/Communicate
Take-off Confined Area	Conduct Term. Nav. Straight	Reposition AC
Transition to Forward Flt (Reg)	Conduct Term. Nav. Spiral	ISR In-bound to TIC
Transition to Fwd Flt (Zoom)	Final Approach	ISR Observation
Transition to Fwd Flt (Confined)	Cabin Door Opening	Scan and ID Targets
Transition to Fwd Flt (Slung Reg)	Landing Hover Regular	Gunnery Attack Run
Transition to Fwd Flt (Sling Confined)	Landing Tactical Regular	Run out and Turn for each Approach
Close Cabin Door	Landing Hover Confined	Detect Threat
Transition to Hover	Landing Sloped	Assess Threat (FP side)
Transition to Level Flt	Landing Visually Obscured	Assess Threat (NFP side)
Transition to Sect. Mov't Lead	Landing Slide to Sling	Movement to Cover
Transition to Sect. Mov't #2	Troops	CONTACT Report
Trans. to Sect. Mov't Lead Confined	Secure Troops/Equip in AC	Post-landing Shutdown
Trans. to Sect. Mov't #2 Confined	Hook up Slung Loads FE Manual	Egress AC
Non-tactical Climb	Take-off with Slung Load	Receive New Tasking
Non-tactical Climb to Contour (<100')	Control AC with Slung Load	Conduct Enroute Flight
Flat Ascent Climb (100-200')	Slung Loads TAMS	Conduct Detailed Planning
Spiral Climb (3000')	FARP Pick-ups	

Table 7: MFTA Mission Sub-Task

Carry Mission Kit to AC	Locate LZ or Chalk	Orient Map with Ground
Load Mission Kit	Transition to Hover	Scan likely EN locations
Conduct Hook Check	Land Helicopter	Choose next Obs location
Open Cabin Door	Control AC at Ground Idle	Assess Terrain/Choose Path
Open and Ingress AC Doors	Embark Troops	NOE Flight
Start-up Engine #1	Load Equipment / Supplies	Assess EN Threat Locations
Last Chance Walk-around #1	Inspect Load	Prep Sensors/Plan Observation
Start-up Engine #2	Hook up Slung Load	Detect threat
Last Chance Walk-around #2	Take-off to Hover over Slung Load	Assess Threat Direction
Pre-take off Checks	Pick up Slung Load	Employ Counter-measures
Secure Cabin Contents	Hover over Load	Choose Flight Path
Taxi to Hold Area	Hook up Load	Reposition behind Cover
Conduct En-route Navigation	Lift to Hover	Transmit CONTACT Report
Update Mission	Hot Re-fuel	Record Threat Position
Report at Report Lines	Load Supplies	Choose Evasive Maneuver
Control AC in Holding Pattern	Transition to Hover w Slung Load	Conduct Evasive Maneuver
Conduct Re-bro Relay	Set Load on Ground	Download Mission Data
Transition to Contour Flight	Pilot Releases Load	Complete Shutdown
Control AC during Contour Flt	Hover with Slung Load	Unload Flight Crew Equipment
Control AC during Transit	Set Load on Pallet	Receive Request
Conduct Pre-Landing Checks	Assess Enemy Location/Threat	Discuss New Tasking
Conduct Terminal Navigation	Plan Use/Prepare Sensors	Initial Estimates for Feasibility
Monitor other AC	Plan ISR Profile	Communicate Intent

A total of 50 representative postural sequences were identified and defined, and this information was also catalogued into the Mission Task Library – 12 for the FP (Table 8), 12 for the NFP (Table 9), and 26 for the FE (Table 10).

Table 8: Postural Sequences – Flying Pilot

AC Egress	Outside Scan Chin Bubble
Hard Turn FP Side	Outside Scan Confined
Hard Turn NFP Side	Outside Scan Regular
Inside Scan Ceiling Switches	Outside Scan Wide
AC Ingress	Rapid Scanning
Inside Scan Dash Gauges	Walking

Table 9: Postural Sequences – Non-flying Pilot

AC Egress	Map/Doc Referencing
CDU/AMS Use	MX-15 Use
Hard Turn NFP Side	Outside Scan Confined
Inside Scan Ceiling Switches	Outside Scan Regular
AC Ingress	Rapid Scanning
Inside Scan Dash Gauges	Walking

Table 10: Postural Sequences – Flight Engineer

2-Full Check	Rappelling – Short Approach	Scan Slung Load
Door Closing Seated	Rappelling – Long Approach	Scan Troops on Sill
Door Gunnery – C6	Scan Confined	Sling Hook-up Manual
Door Gunnery – C6 Reload	Scan during Slide to Sling	Transit Seated
Door Opening Inside	Scan NFP Side	Sling Unhook Manual
Door Closing Outside	Scan Regular Landing	Start-up/Last Chance Insp.
Door Opening Outside	Scan Regular Take-off	Walking
Equipment Handling Inside	Scan Seated Door Closed	Ingress
Equipment Handling Outside	Scan Sloped Landing	

Subsequently, each of the 95 unique mission tasks was assigned timings based on the "typical duration" for a "typical mission" for both day and night flights, and each of the 95 tasks were also populated with the Postural Sequence(s) that were required for each of the three roles (FP, NFP, FE) to successfully carry out the task. In other words, based on these postural sequences for all aircrew positions it is possible to simulate the postural, biomechanical demands of tasks in any mission. An example output from the Mission Task Library is provided in Figure 7.

Task	Duration (sec)	FP Postural Seq.	% Dur.	NFP Postural Seq.	% Dur.	FE Postural Seq.	% Dur.
Review Terminal Navigation	60	Outside Scan Regular	90	Outside Scan Regular	40	Scan Seated Door Closed	100
		Inside Scan Dash Gauges	10	Map/Doc Referencing	60		
2-Full Check FE	15	Outside Scan Regular	95	Outside Scan Regular	50	2-Full Check	100
		Inside Scan Dash Gauges	5	Inside Scan Dash Gauges	50		
Conduct Terminal Navigation	120	Outside Scan Regular	95	Outside Scan Regular	80	Scan Seated Door Closed	100
		Inside Scan Dash Gauges	5	Map/Doc Referencing	15		
				Inside Scan Dash Gauges	5		
Final Approach	30	Outside Scan Regular	95	Outside Scan Regular	50	Scan Seated Door Closed	100
		Inside Scan Dash Gauges	5	Inside Scan Dash Gauges	50		
Cabin Door Opening	10	Outside Scan Regular	95	Outside Scan Regular	50	Door Opening Inside	100
		Inside Scan Dash Gauges	5	Inside Scan Dash Gauges	50		
Landing Hover Regular	10	Outside Scan Regular	95	Outside Scan Regular	50	Scan Regular Landing	100
		Inside Scan Dash Gauges	5	Inside Scan Dash Gauges	50		

Figure 7: Mission Task Library Output

4.1.2 Mission Builder

The data from the Mission Task Library was then organized to create the Mission Builder tool. Within this tool the 21 mission blocks, 95 mission tasks and 69 mission sub-tasks were systematically grouped into logically occurring task blocks as a function of mission phase requirements. For instance, the mission tasks Load Mission Kit, Mission Kit Check (Hook), Open and Ingress AC, Start-up/Last Chance Insp., Post-start Checks, and Pre-departure Checks were always required during the Pre-flight phase and were therefore grouped accordingly into a task block. Similarly the mission tasks Pre-taxi Checks, Take-off to Hover Regular, Taxi Field were required during the Taxi (Airport) phase and were grouped into another task block (Figure 8). By means of the Mission Builder tool, users are therefore able to piece together these individual task blocks to create and define an infinite number of customizable composite missions.

The contents of the Mission Task Library, the process of using mission blocks, and the mission builder approach were discussed with aircrew at 400 Sqn. Aircrew reviewed and verified the content of the Mission Task Library and, working through a number of example mission builds, confirmed the validity of employing a mission builder approach to constructing new composite missions.

Mission Block	Mission Task	Duration (sec)	FP Postural Seq.	% Dur.	NFP Postural Seq.	% Dur.	FE Postural Seq.	% Dur.
PRE-FLIGHT	Load Mission Kit	600	Walking	100	Walking	100	Walking	80
PRE-FLIGHT	Mission Kit Check (Hook)	120	Inside Scan Dash Gauges	100	Inside Scan Dash Gauges	100	Sling Hook-up Manual	100
PRE-FLIGHT	Open and Ingress AC	300	AC Ingress	100	AC Ingress	100	Door Opening Outside	100
PRE-FLIGHT	Start-up/Last Chance Insp.	600-900	Outside Scan Regular	25	Outside Scan Regular	20	Start-up/Last Chance Insp.	100
PRE-FLIGHT	Post-start Checks	60	Outside Scan Regular	50	Outside Scan Regular	20	Equipment Handling Inside	100
PRE-FLIGHT	Pre-departure Checks	60	Outside Scan Regular	95	Outside Scan Regular	50	Scan Regular Take-off	100
TAXI (Field)	Pre-taxi Checks	25	Outside Scan Regular	95	Inside Scan Dash Gauges	50	Scan Seated Door Closed	100
TAXI (Field)	Take-off to Hover Regular	20	Outside Scan Regular	95	Outside Scan Regular	50	Scan Regular Take-off	100
TAXI (Field)	Taxi Field	60	Outside Scan Regular	85	Outside Scan Regular	50	Scan Regular Take-off	100
TAXI (Airport)	Pre-Takeoff Checks	30	Inside Scan Dash Gauges	95	Outside Scan Regular	50	Equipment Handling Inside	100
TAXI (Airport)	Take-off to Hover Regular	20	Outside Scan Regular	95	Outside Scan Regular	50	Scan Regular Take-off	100
TAXI (Airport)	Post-Take off Checks	60-120	Outside Scan Regular	85	Outside Scan Regular	50	Scan Regular Take-off	100
TAXI (Airport)	Pre-taxi Checks	25	Outside Scan Regular	95	Inside Scan Dash Gauges	50	Scan Seated Door Closed	100
TAXI (Airport)	Taxi to Hold Area	60	Outside Scan Regular	85	Outside Scan Regular	50	Scan Regular Take-off	100
TAXI (Airport)	Land at Hold Area	10	Outside Scan Regular	95	Outside Scan Regular	50	Scan Regular Landing	100
TAXI (Airport)	Obtain IFR Clearance	60	Outside Scan Regular	50	CDU/AMS Use	100	Scan Regular Take-off	100
TAKE-OFF (Hover)	Pre-Takeoff Checks	30	Inside Scan Dash Gauges	95	Outside Scan Regular	50	Equipment Handling Inside	100
TAKE-OFF (Hover)	Take-off to Hover Regular	20	Outside Scan Regular	95	Outside Scan Regular	50	Scan Regular Take-off	100

Figure 8: Mission Builder Tool

4.2 PDA

The PDA Library and the results of the postural sequence demands for all three aircrew roles are described below.

4.2.1 PDA Library

The PDA Library includes an Excel file of all PDA worksheets for all 7 Flying Pilots and Non-Flying Pilots, and all 6 Flight Engineers. As well, a summary datasheet is provided for each postural sequence, day and night, with mean values for all measures and representative parameter graphs.

Owing to the size of the PDA Library, the summary PDA datasheets for each postural sequence, day and night, are provided as a companion document to this main report: Griffon Helicopter Neck Strain Project: Part 2: Physical Demands Analysis Library.

4.2.2 Postural Sequence Demands

Postural sequence demands for postures, forces, and moments are described below for all aircrew.

4.2.2.1 Postures

Postural data are described below for the FE, FP, and NFP.

4.2.2.1.1 Flight Engineer

The following joint angle profiles were calculated for the 22 FE postural sequences in day and night conditions:

- flexion/extension,
- left/right axial rotation, and
- left/right lateral bend.

Sample joint angle profiles and average results amongst the six FEs can be found on in the PDA workbooks shown in the companion document, Griffon Helicopter Neck Strain Project: Part 2: Physical Demands Analysis Library.

The two joint motions that resulted in the largest average joint angles were flexion and right axial rotation. Table 11 and Table 12 summarize the five postures with the highest average joint angle for flexion and right axial rotation for both day and night conditions. It is anticipated that left axial rotation resulted in lower average values than right axial rotation because, for our data collection, the FE was on the right side of the AC and therefore right axial rotation is the motion that allows the FE to monitor the tail rotor of the AC. For a complete summary of the joint angle results for all 22 of the FE postural sequences see Annex B.

Table 11: Flight Engineer Average Neck Flexion

Day			Night		
Rank	Postural Sequence	Flexion (degrees)	Rank	Postural Sequence	Flexion (degrees)
1	Scan Slung Load	-25.05	1	Scan Slung Load	-38.26
2	Ingress	-22.88	2	Scan Slope Landing	-31.68
3	Scan Seated Door Closed	-22.60	3	Scan Confined	-28.23
4	Door Closing Seated	-21.52	4	Scan Regular Take-Off	-23.10
5	Sling Hook Up Manual	-19.98	5	Ingress	-23.06

Table 12: Flight Engineer Average Neck Right Axial Rotation

Day			Night		
Rank	Postural Sequence	Right Axial Rotation (degrees)	Rank	Postural Sequence	Right Axial Rotation (degrees)
1	Scan Troops on Sill	-51.31	1	Scan Seated Door Closed	-50.65
2	Scan Regular Landing	-45.48	2	Scan NFP Side	-44.82
3	Scan Confined	-43.97	3	Scan Regular Take Off	-39.79
4	Scan Seated Door Closed	-41.73	4	Scan Regular Landing	-39.02
5	Scan Slope Landing	-35.60	5	Transit Seated	-37.03

In both flexion and right axial rotation, postural sequences involving scanning are the predominant contributors to high average joint angles. This is expected because scanning tasks would involve the largest amount of head motion.

The average flexion results show the general trend that flexion increases in the night condition. This result was anticipated because NVGs are known to reduce field of view and therefore would require more head movement to see the points of interest around the helicopter. Conversely the same trend is not seen in the right axial rotation results where day and night averages were relatively the same. However, the expected trend of greater time spent in right axial rotation is noted when comparing the time spent in different posture zones between day and night conditions. The average percent of time, relative to the total postural sequence duration, spent in the neck posture zones outlined in Table 4, was calculated for all 22 FE postural sequences. The average for all scanning FE tasks is shown in Figure 9. For a complete summary see Annex B. It was observed that, in general, the night condition resulted in an increase in percent of time spent in ROM zones that are classified as severe for FE postural sequences that predominantly involved scanning.

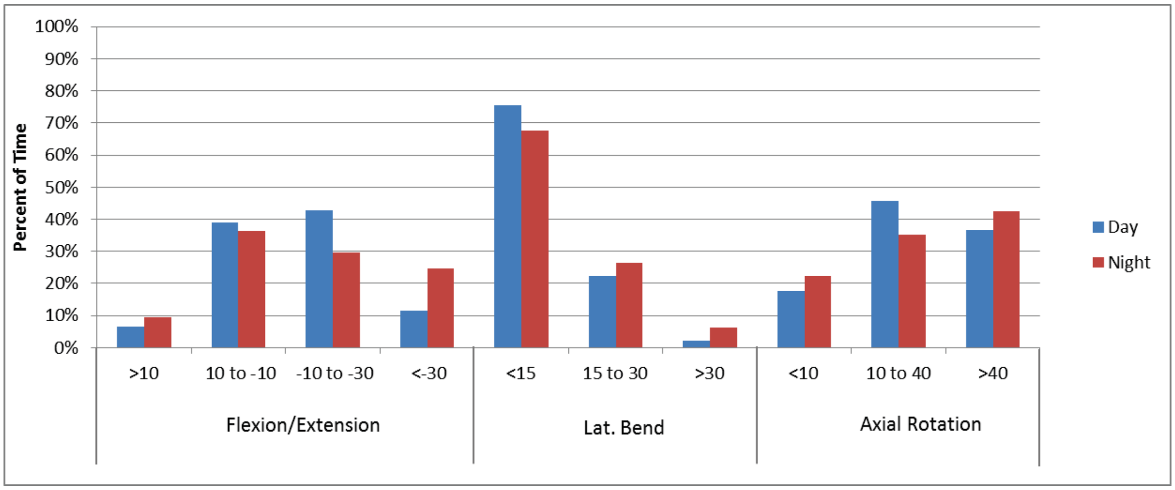

Figure 9: Flight Engineer Percent of Total Scanning Duration Spent in ROM Zones

For all three axis of rotation, more time is spent in the severe posture zones in night operations, as compared to the day operations. This supports the results from Table 11 and Table 12 that showed average joint angles increasing in the night condition.

4.2.2.1.2 Flying Pilot

The following joint angles were calculated for the 12 FP postural sequences in day and night conditions:

- flexion/extension,
- left/right axial rotation, and
- left/right lateral bend.

Sample joint angle profiles and average results amongst the seven FPs can be found on in the PDA workbooks shown in the companion document, Griffon Helicopter Neck Strain Project: Part 2: Physical Demands Analysis Library.

The three joint motions that resulted in the largest joint angles were flexion, and left and right axial rotation. Furthermore, Table 13 –Table 18 summarize the five postures with the highest average joint angle for flexion, and left and right axial rotation for both day and night conditions. For a complete summary of the joint angle results for all 12 of the FP postural sequences see Annex B.

Table 13: Flying Pilot Average Neck Flexion

Day			Night		
Rank	Postural Sequence	Flexion (degrees)	Rank	Postural Sequence	Flexion (degrees)
1	Outside Scan Chin Bubble	-43.70	1	Outside Scan Chin Bubble	-47.86
2	AC Ingress	-38.71	2	AC Ingress	-35.66
3	AC Egress	-34.45	3	AC Egress	-31.98
4	Inside Scan Dash Gauges	-28.51	4	Outside Scan Confined	-28.70
5	Outside Scan Confined	-27.06	5	Outside Scan Wide	-23.29

Table 14: Flying Pilot Average Neck Left Axial Rotation

Day			Night		
Rank	Postural Sequence	Left Axial Rotation (degrees)	Rank	Postural Sequence	Left Axial Rotation (degrees)
1	Inside Scan Ceiling Switches	41.45	1	Hard Turn NFP Side	46.97
2	Hard Turn NFP Side	36.94	2	Inside Scan Ceiling Switches	43.05
3	Outside Scan Wide	34.12	3	Outside Scan Wide	31.68
4	Outside Scan Confined	24.88	4	Hard Turn FP Side	23.28
5	Outside Scan Regular	18.86	5	AC Ingress	21.17

Table 15: Flying Pilot Average Neck Right Axial Rotation

Day			Night		
Rank	Postural Sequence	Right Axial Rotation (degrees)	Rank	Postural Sequence	Right Axial Rotation (degrees)
1	Hard Turn FP Side	-45.90	1	Hard Turn FP Side	-48.81
2	Rapid Scanning	-31.31	2	Rapid Scanning	-42.70
3	Outside Scan Wide	-29.35	3	Outside Scan Wide	-33.06
4	Outside Scan Confined	-26.67	4	Outside Scan Confined	-31.37
5	AC Ingress	-22.13	5	Hard Turn NFP Side	-25.18

The FP postural sequences that contribute most to high average neck flexion and axial rotation are predominantly outside scanning in unique situations such as using the chin bubble, in a confined space, or when performing a hard turn. This is expected because those postures require the FP to scan the peripheral of the AC while being confined to their seated posture and thus require large amounts of head motion.

In general, when comparing the results for day and night conditions the night condition resulted in higher average joint angles. Again, this trend is most significant in postures that require outside scanning of the peripheral of the AC, which is expected because NVGs reduce field of view.

Average percent of time, relative to the total postural sequence duration, spent in the neck posture zones outline in Table 4, was calculated for all 12 FP postural sequences. The average for all scanning FP tasks is shown in Figure 10. For a complete summary see Annex B. It was observed

that, in general, the night condition resulted in a decrease in time spent in neutral zones and an increase in time spent moderate and severe zones for FP postural sequences that predominantly involved scanning.

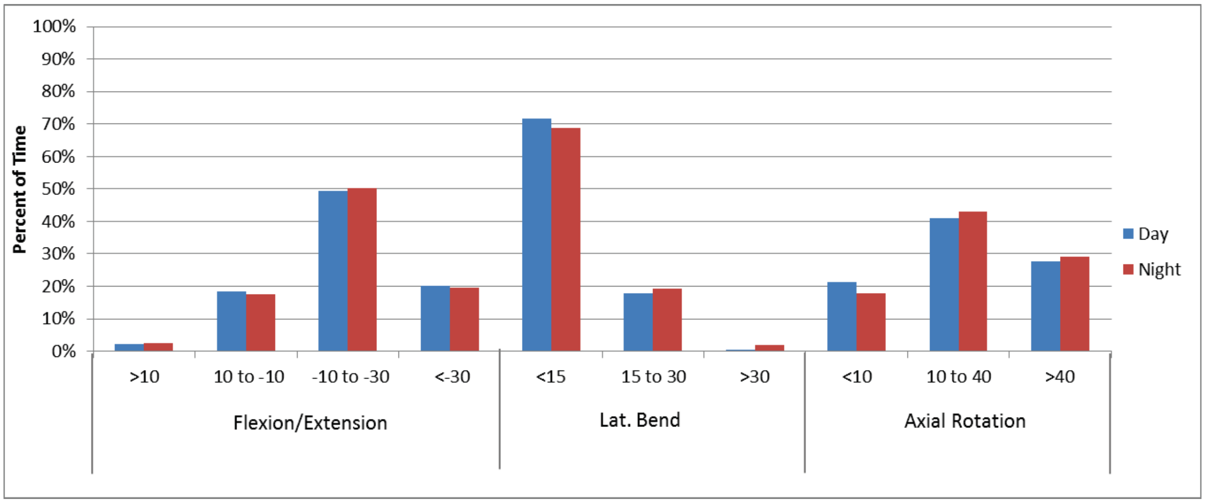

Figure 10: Flying Pilot Percent of Total Scanning Duration Spent in ROM Zones

4.2.2.1.3 Non-Flying Pilot

The following joint angles were calculated for the 12 NFP postural sequences in day and night conditions:

- flexion/extension,
- left/right axial rotation, and
- left/right lateral bend.

Sample joint angle profiles and average results amongst the seven NFPs can be found on in the PDA workbooks shown in companion document, Griffon Helicopter Neck Strain Project: Part 2: Physical Demands Analysis Library.

The three joint motions that resulted in the largest joint angles were flexion, and left and right axial rotation. Furthermore, Table 16 – Table 18 summarize the five postures with the highest average joint angle for flexion, and left and right axial rotation for both day and night conditions. For a complete summary of the joint angle results for all 12 of the NFP postural sequences see Annex B.

Table 16: Non-Flying Pilot Average Neck Flexion

Day			Night		
Rank	Postural Sequence	Flexion (degrees)	Rank	Postural Sequence	Flexion (degrees)
1	MX15 Use	-67.45	1	AC Ingress	-37.82
2	CDU AMS Use	-43.35	2	AC Egress	-36.05
3	Map Doc Referencing	-40.06	3	CDU AMS Use	-33.05
4	AC Ingress	-38.70	4	Map Doc Referencing	-27.49
5	AC Egress	-33.40	5	Outside Scan Confined	-25.92

The NFP postures that contribute most to the large average neck flexion values are predominantly postures that involve reference equipment inside the AC, such as using the MX-15, CDU and referencing maps. This is expected because these types of postures require the NFP to look at equipment that is relative close to their body and down around waist height.

When comparing neck flexion for night and day conditions there is an interesting trend in that the major contributors to high flexion during the day actually have a lower average neck flexion in the night condition. It is hypothesised that the NFP is looking underneath the NVGs to see their equipment instead of looking through the NVG lenses. This was a technique that both FEs and pilots discussed during the MFTA interviews.

Table 17: Non-Flying Pilot Average Neck Left Axial Rotation

Day			Night		
Rank	**Postural Sequence**	**Left Axial Rotation (degrees)**	**Rank**	**Postural Sequence**	**Left Axial Rotation (degrees)**
1	Rapid Scanning	55.31	1	Rapid Scanning	55.58
2	Hard Turn NFP Side	51.66	2	Hard Turn NFP Side	51.42
3	Outside Scan Confined	32.71	3	Outside Scan Confined	36.93
4	AC Egress	27.90	4	Outside Scan Regular	33.32
5	Outside Scan Regular	25.70	5	AC Egress	32.47

Table 18: Non-Flying Pilot Average Neck Right Axial Rotation

Day			Night		
Rank	**Postural Sequence**	**Right Axial Rotation (degrees)**	**Rank**	**Postural Sequence**	**Right Axial Rotation (degrees)**
1	Rapid Scanning	-37.75	1	Rapid Scanning	-62.49
2	Inside Scan Ceiling Switches	-37.09	2	MX15 Use	-36.59
3	Hard Turn NFP Side	-32.73	3	Inside Scan Ceiling Switches	-33.07
4	CDU AMS Use	-32.41	4	CDU AMS Use	-26.22
5	Outside Scan Regular	-25.90	5	Outside Scan Confined	-24.99

The NFP postures that contribute most to left and right axial rotation are predominantly postures that involve outside scanning in unique situations and postures that require the NFP to observe equipment inside the AC. With respect to outside scanning, this is expected because outside scanning in unique situations such as rapid scanning or scanning in a confined space requires that the NFP observe the periphery of the AC while being restricted to their seated posture. With respect to observing equipment inside the AC, this is also expected because the equipment is typically located close to their seats but either up on the ceiling or lower by their waist and therefore severe head postures are required to gain proper sight lines.

When comparing the axial rotation results between day and night conditions the expected trend was not observed, where night would lead to increased rotation because of the reduction in field of view. It is hypothesised that the trend was not observed because the NFP will sometimes adapt their posture in order to not look through the NVG lenses but actually look underneath the NVGs for tasks that require them to look at equipment inside the AC.

Average percent of time, relative to the total postural sequence duration, spent in the neck posture zones outline in Table 4, was calculated for all 12 NFP postural sequences. The average for all scanning NFP tasks is shown in Figure 11. For a complete summary see Annex B. The trends observed with FE and FP scanning tasks was not as predominant with the NFP results. However it is still observed that the night condition typically led to a decrease in time spent in neutral posture zones and subsequently an increase in time spend in moderate posture zones.

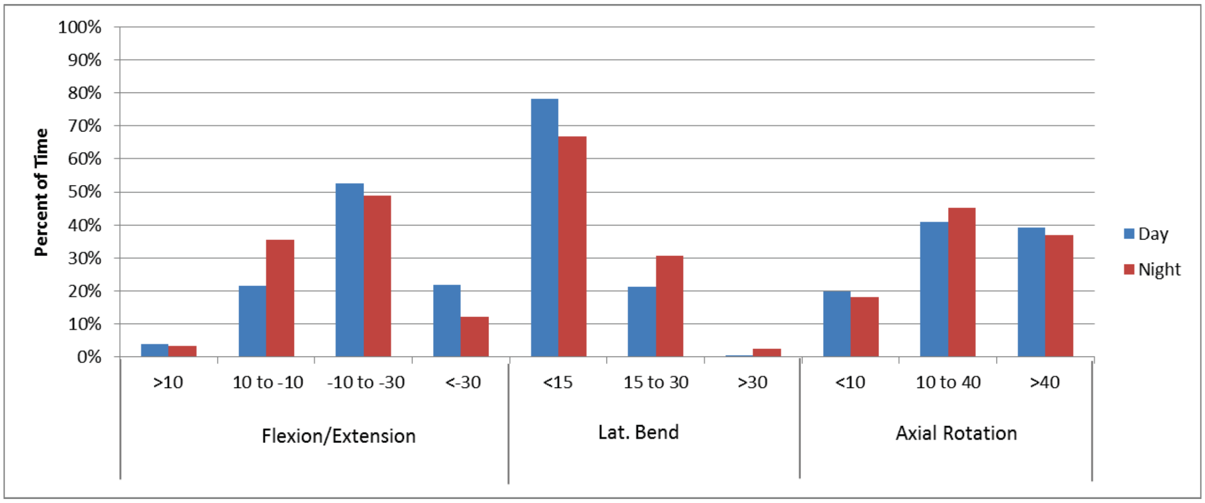

Figure 11: Non-Flying Pilot Percent of Total Postural sequence Duration Spent in ROM Zones for Scanning Postures

4.2.2.2 Forces and Moments

The following neck joint torques and forces were calculated for each of the FE, FP and NFP postural sequences:

- flexion/extension torque,
- axial rotation torque,
- lateral bend torque, and
- the resultant neck torque,
- compression/tension force,
- anterior/posterior shear force, and
- left/right lateral shear force.

Sample torque and force profiles and average results can be found on each PDA workbook located in companion document, Griffon Helicopter Neck Strain Project: Part 2: Physical Demands Analysis Library.

4.2.2.2.1 Flight Engineer

The resultant neck torque, compression and posterior shear forces are discussed in this section since they best describe the physical demands of the FE postural sequences. For graphs of all torques and forces see Annex B. Average resultant neck torque in both day and night conditions is shown in Figure 12.

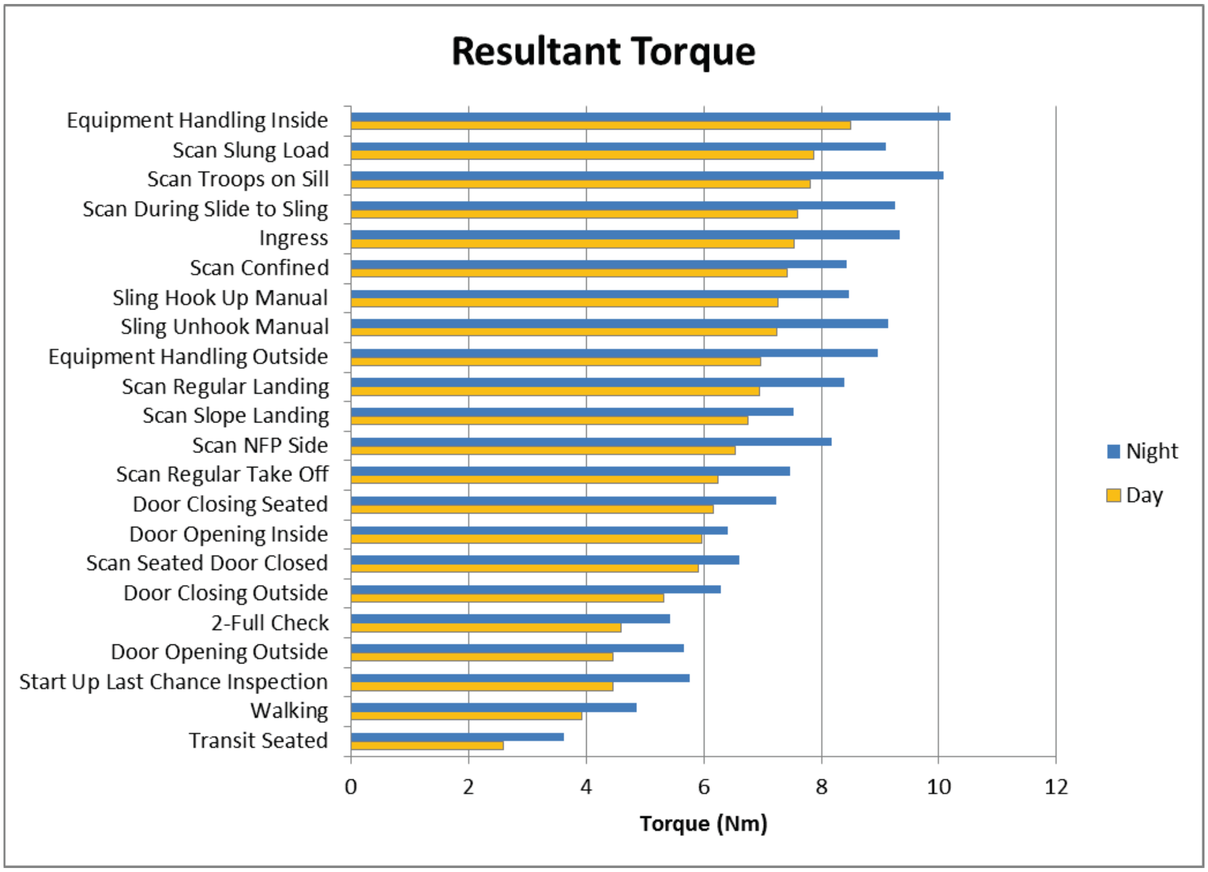

Figure 12: Flight Engineer Average Resultant Neck Torque

The five postures that resulted in the largest average resultant neck torque in the day condition were:

- Equipment Handling Inside, 8.50 N·m;
- Scan Slung Load, 7.86 N·m;
- Scan Troops on Sill, 7.81 N·m;
- Scan During Slide to Sling, 7.59 N·m; and
- Ingress, 7.53 N·m.

The five postures that resulted in the largest average resultant neck torque in the night condition were:

- Equipment Handling Inside, 10.20 N·m;
- Scan Troops on Sill, 10.07 N·m;
- Ingress, 9.33 N·m;
- Scan During Slide to Sling, 9.25 N·m; and
- Sling Unhook Manual, 9.13 N·m.

For all the 22 FE postural sequences the night condition resulted in higher average torque than the day condition. This is due to the combined effect that the NVGs and counter weight have on the helmet mass and center of mass location.

For both day and night conditions, the postural sequences with the highest resultant torque were those that required the FE to position themselves horizontally, either by bending at the waist (Equipment Handling Inside, Scan Troops on Sill) or by leaning out the side of the AC (Scan Slung Load, Scan During Slide to Sling). The reason for high resultant torque during these postures is that the moment arm from the C7 to the center of mass, perpendicular to the force of gravity acting on the helmet, will be largest when the upper body is horizontal.

Average neck compression force in both day and night conditions is shown in Figure 13.

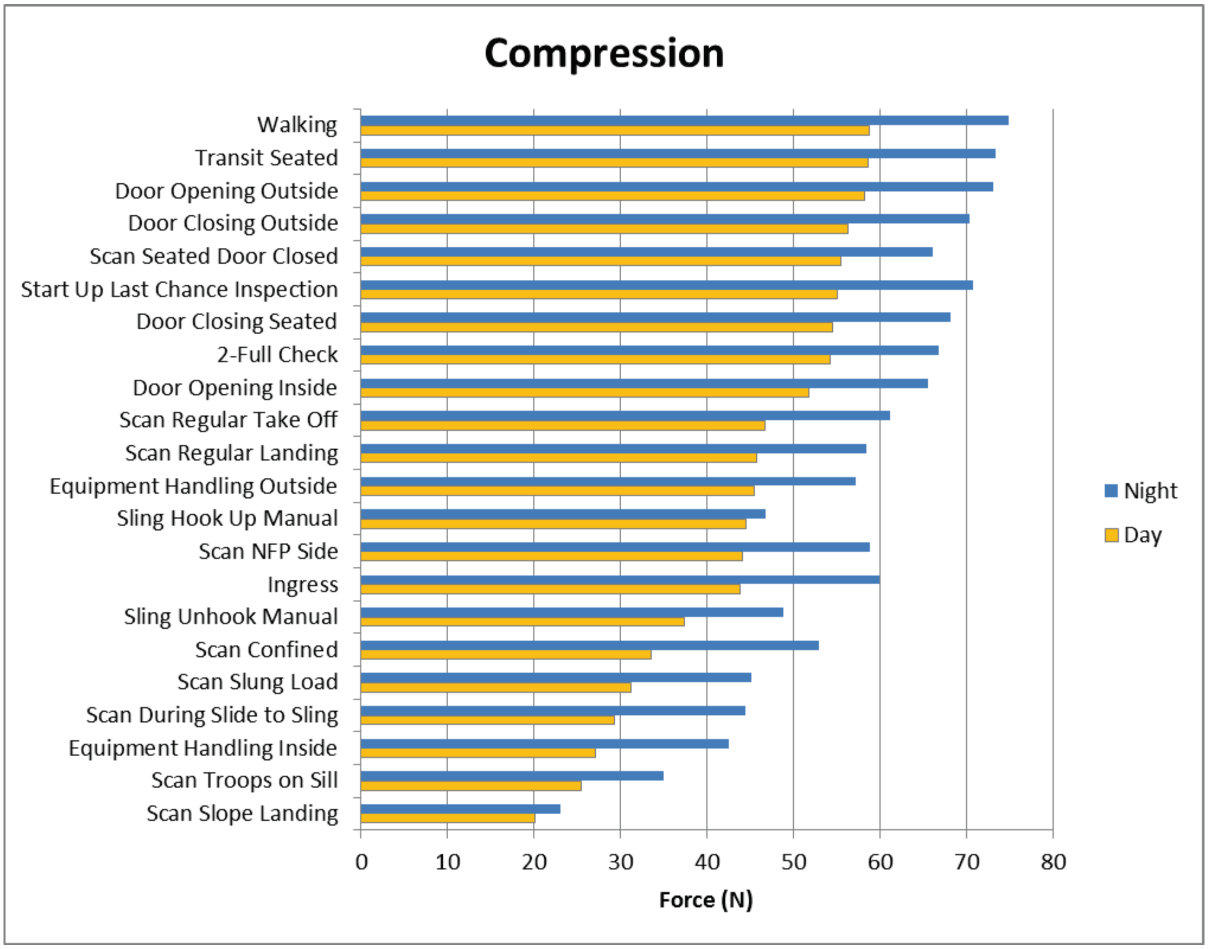

Figure 13: Flight Engineer Average Neck Compression

The five postures that resulted in the largest average neck compression force in the day condition were:

- Walking, 58.80 N;
- Transit Seated, 58.63 N;
- Door Opening Outside, 58.31 N;
- Door Closing Outside, 56.33 N; and
- Scan Seated Door Closed, 55.51 N.

The five postures that resulted in the largest average neck compression force in the night condition were:

- Walking, 74.92 N;
- Transit Seated, 73.36 N;
- Door Opening Outside, 73.07 N;
- Start up Last Chance Inspection, 70.82 N; and
- Door Closing Outside, 70.35 N.

All 22 FE postural sequences resulted in higher compression forces in the night condition, as compared to the day condition. This is due to the increase in helmet weight when adding the NVGs and counter weight.

In contrast to the resultant torque summary findings, the types of FE postural sequences that had the highest average compression force where ones that required the torso and neck to be vertical. This type of body posture occurred during postural sequences that required sitting or standing up straight with minimal neck flexion. This is expected because with this type of body posture the largest portion of the vertical force of gravity will be acting on the compression axis at the neck.

Average neck posterior shear force in both day and night conditions is shown in Figure 14.

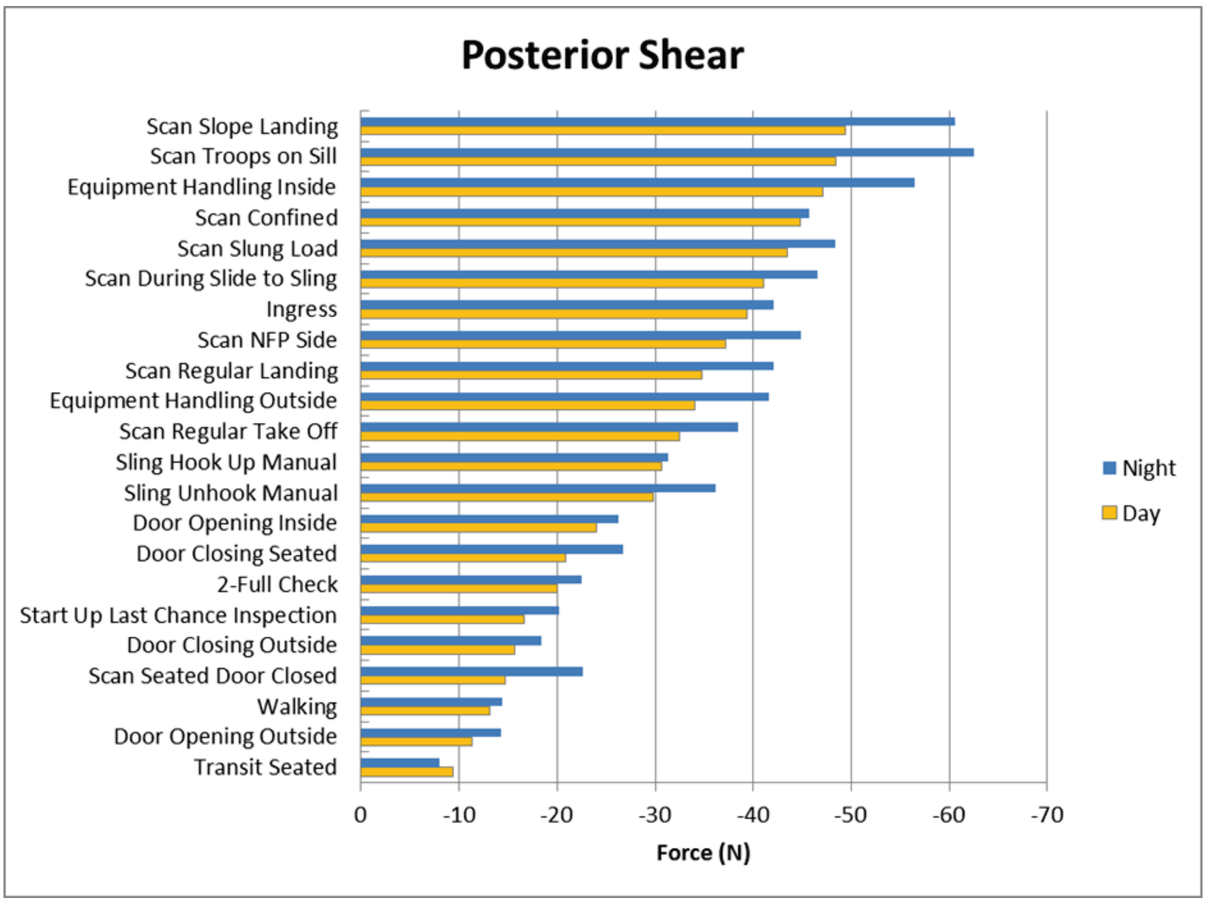

Figure 14: Flight Engineer Average Neck Posterior Shear

The five postures that resulted in the largest average neck posterior shear force in the day condition were:

- Scan Slope Landing, -49.45 N;
- Scan Troops on Sill, -48.42 N;
- Equipment Handling Inside, -47.05 N;
- Scan Confined, -44.82 N; and
- Scan Slung Load, -43.42 N.

The five postures that resulted in the largest average neck posterior shear force in the night condition were:

- Scan Troops on Sill, -62.54 N;
- Scan Slope Landing, -60.52 N;
- Equipment Handling Inside, -56.41 N;
- Scan Slung Load, -48.33 N; and
- Scan During Slide to Sling, -46.53 N.

In all postural sequences, except for transit seated, the average posterior shear increased in the night condition. This is expected because of the increase in weight when adding the NVGs and counter weight.

Similarly to resultant torque results, the postural sequences that led to the highest average posterior shear values were those that required the FE to position themselves horizontally, either by bending at the waist or by leaning out the side of the AC. This is expected because this type of body posture would result in the largest portion of the vertical force of gravity acting in the direction of the posterior/anterior axis.

4.2.2.2.2 Flying Pilot

The resultant neck torque, compression and posterior shear forces were observed to best describe the physical demands of the FP postural sequences. For graphs of all torques and forces see Annex B. The average resultant torque in both day and night conditions is summarized in Figure 15.

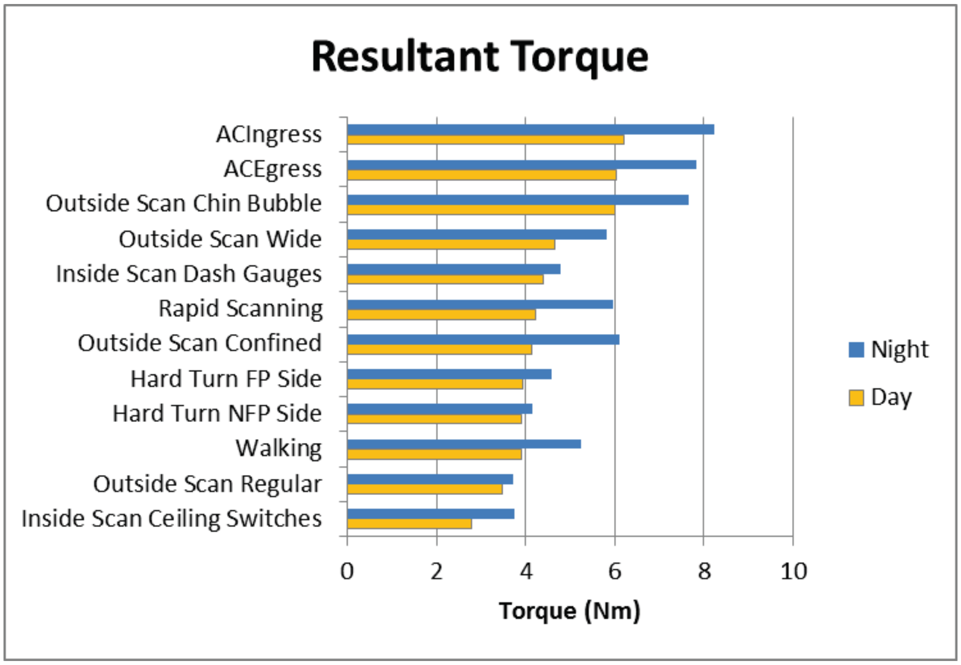

Figure 15: Flying Pilot Average Resultant Neck Torque

The five postures that resulted in the largest average resultant neck torque in the day condition were:

- AC Ingress, 6.23 N·m;
- AC Egress, 6.03 N·m;
- Outside Scan Chin Bubble, 6.01 N·m;
- Outside Scan Wide, 4.64 N·m; and
- Inside Scan Dash Gauges, 4.40 N·m.

The five postures that resulted in the largest average resultant neck torque in the night condition were:

- AC Ingress, 8.23 N·m;
- AC Egress, 7.84 N·m;
- Outside Scan Chin Bubble, 7.51 N·m;
- Outside Scan Confined, 7.67 N·m; and
- Rapid Scanning, 6.09 N·m.

All 12 FP postural sequences resulted in higher resultant torque in the night condition, as compared to the day condition. This was expected because of the combined effect that adding the NVGs and counter weight would have on the helmet mass and center of mass location.

Other than ingress and egress, the postural sequences that had the highest average resultant torque were those that required outside scanning in unique situations such as using the chin bubble, in a confined space, and rapid scanning. This correlates with the posture results discussed in section 4.2.2.1.2. High resultant torque values in these postures is expected because they require the FP to

adopt body postures that would move the helmet center of mass further away from the base of the neck and thus increase the perpendicular moment arm from the C7 to the helmet center of mass.

The average neck compression force in both day and night conditions is summarized in Figure 16.

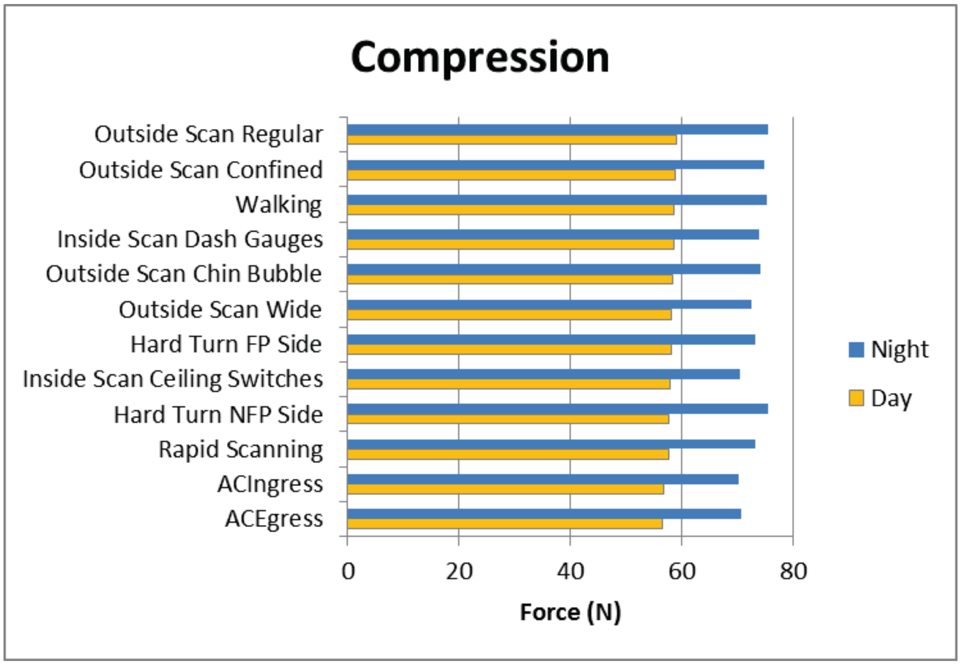

Figure 16: Flying Pilot Average Neck Compression

The five postures that resulted in the largest average neck compression force in the day condition were:

- Outside Scan Regular, 59.19 N;
- Outside Scan Confined, 58.77 N;
- Walking, 58.73 N;
- Inside Scan Dash Gauges, 58.72 N; and
- Outside Scan Chin Bubble, 58.36 N.

The five postures that resulted in the largest average neck compression force in the night condition were:

- Hard Turn NFP Side, 75.60 N;
- Outside Scan Regular, 75.44 N;
- Walking, 75.36 N;
- Outside Scan Confined, 74.84 N; and
- Outside Scan Chin Bubble, 74.24 N.

All 12 FP postural sequences had higher average compression force in the night condition, as compared to the day condition. This is due to the increase in mass when adding the NVGs and counter weight.

Very little compression force variation was observed between FP postural sequences, which are likely due to the fact that these postures predominantly seated tasks. This forces the upper body to be vertical and thus increases the portion of the vertical force of gravity acting on the helmet that is in line with the compression axis at the neck.

The average resultant torque in both day and night conditions is summarized in Figure 17.

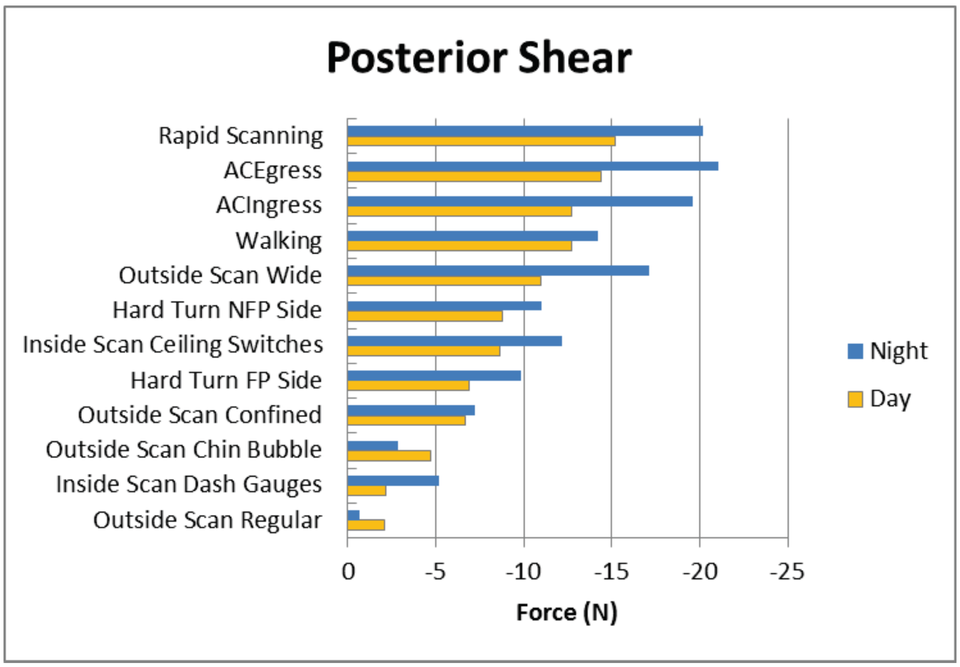

Figure 17: Flying Pilot Average Neck Posterior Shear

The five postures that resulted in the largest average neck posterior shear force in the day condition were:

- Rapid Scanning, -15.20 N;
- AC Egress, -14.37 N;
- AC Ingress, -12.74 N;
- Walking, -12.73 N; and
- Outside Scan Wide, -10.99 N.

The five postures that resulted in the largest average neck posterior shear force in the night condition were:

- AC Egress, -21.09 N;
- Rapid Scanning, -20.16 N;

- AC Ingress, -19.64 N;
- Outside Scan Wide, -17.14 N; and
- Walking, -14.24 N.

The majority of FP postural sequences resulted in higher average posterior shear force in the night condition, as compared to the day condition. This is due to the combined effect that adding NVGs and counter weight has on the helmet mass and center of mass.

Similarly to the resultant torque summary, the FP postural sequences, other than ingress and egress, that contributed most to higher average posterior shear were those that required outside scanning in unique situations. Higher average posterior shear results is also expected with these types of postures because when the upper body become more horizontal a larger portion of the vertical force of gravity will be acting in the direction of the posterior/anterior axis.

4.2.2.2.3 Non-Flying Pilot

The resultant neck torque, compression and posterior shear forces were observed to best describe the physical demands of the NFP postural sequences. For graphs of all torques and forces see Annex B. The average resultant torque in both day and night conditions is summarized in Figure 18.

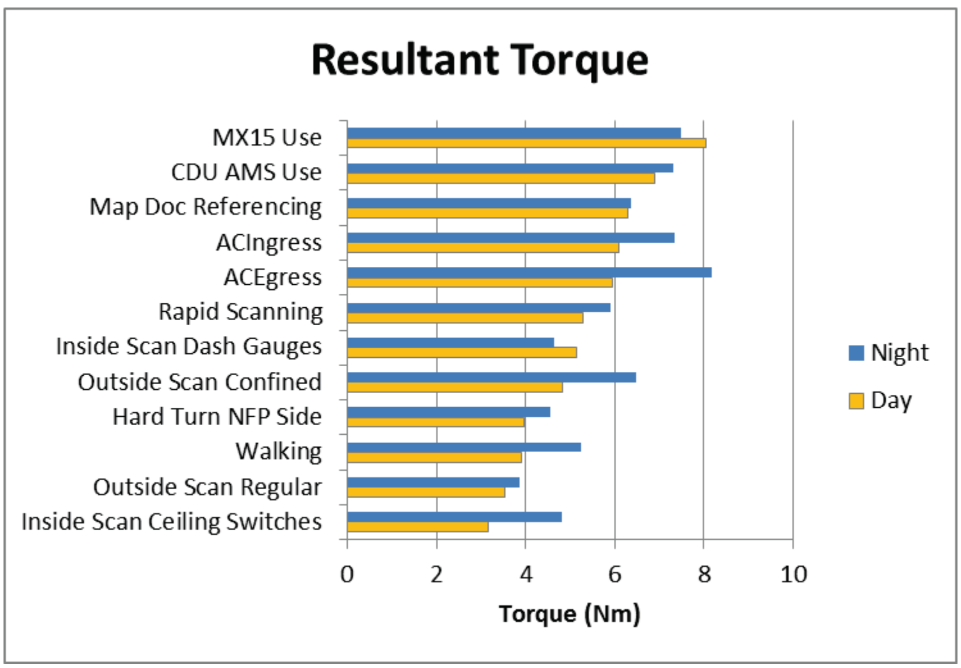

Figure 18: Non-Flying Pilot Average Resultant Neck Torque

The five postures that resulted in the largest average resultant neck torque in the day condition were:

- MX15 Use, 8.06 N·m;
- CDU AMS Use, 6.90 N·m;
- Map Doc Referencing, 6.29 N·m;

* AC Ingress, 6.09 N·m; and
* AC Egress, 5.94 N·m.

The five postures that resulted in the largest average resultant neck torque in the night condition were:

* AC Egress, 8.19 N·m;
* MX15 Use, 7.48 N·m;
* AC Ingress, 7.34 N·m;
* CDU AMS Use, 7.31 N·m; and
* Outside Scan Confined, 6.49 N·m.

Ten of the NFP postural sequences had higher average resultant torque in the night condition, as compared to the day condition. This is due to the combined effect that adding the NVGs and counter weight has on the helmet mass and center of mass location.

Other than ingress and egress the NFP postural sequences that predominantly contribute to higher average resultant torque are those that require the NFP to look at equipment inside the AC. Looking at equipment inside the AC requires the NFP to adopt irregular postures where there upper body and neck are flexed, as shown in the posture analysis. This causes the perpendicular moment arm from the C7 to the helmet center of mass to increase in length and therefore increase the resultant torque.

The average resultant torque in both day and night conditions is summarized in Figure 19.

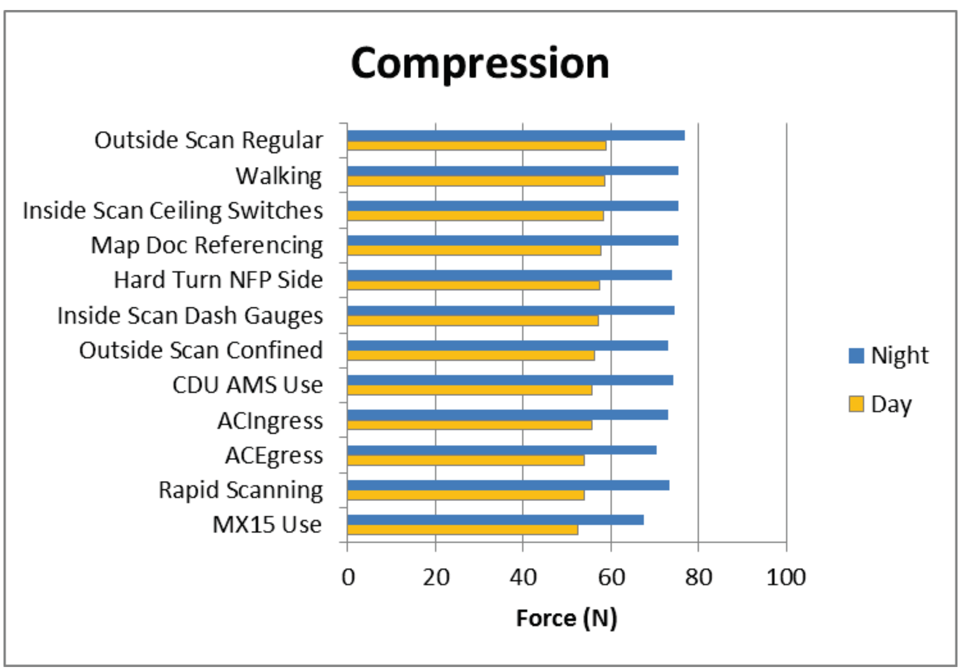

Figure 19: Non-Flying Pilot Average Neck Compression

The five postures that resulted in the largest average neck compression force in the day condition were:

- Outside Scan Regular, 58.79 N;
- Walking, 58.73 N;
- Inside Scan Ceiling Switches, 58.33 N;
- Map Doc Referencing, 57.64 N; and
- Hard Turn NFP Side, 57.46 N.

The five postures that resulted in the largest average neck compression force in the night condition were:

- Outside Scan Regular, 76.90 N;
- Map Doc Referencing, 75.56 N;
- Inside Scan Ceiling Switches, 75.48 N;
- Walking, 75.36 N; and
- Inside Scan Dash Gauges, 74.52 N.

All of the NFP postural sequences resulted in higher average neck compression force in the night condition, as compared to the day condition, due to the increase in weight when the NVG and counter weight are added.

There were relatively small variations between NFP postural sequences with respect to the average compression force due to the fact that all postures predominantly require the NFP to be seated. This forces the upper body to be vertical and thus increases the portion of the vertical force of gravity acting on the helmet that is in line with the compression axis at the neck.

The average resultant torque in both day and night conditions is summarized in Figure 20.

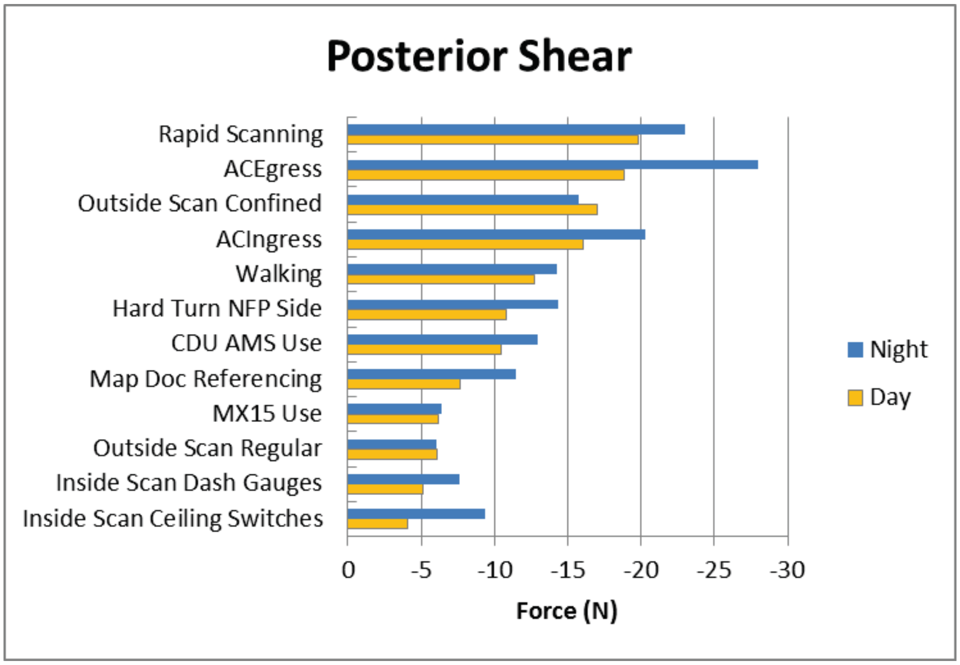

Figure 20: Non-Flying Pilot Average Neck Posterior Shear

The five postures that resulted in the largest average neck posterior shear force in the day condition were:

- Rapid Scanning, -19.84 N;
- AC Egress, -18.84 N;
- Outside Scan Confined, -17.04 N;
- AC Ingress, -16.04 N; and
- Walking, -12.73 N.

The five postures that resulted in the largest average neck posterior shear force in the night condition were:

- AC Egress, -27.95 N;
- Rapid Scanning, -23.01 N;
- AC Ingress, -20.30 N;
- Outside Scan Confined, -15.76 N; and
- Hard Turn NFP Side, -14.37 N.

Ten of the 12 NFP postural sequences resulted in higher average posterior shear in the night condition, as compared to the day condition. This is due to the combined effect of adding the NVGs and counter weight has on helmet mass and center of mass location.

Other than ingress egress, the NFP postural sequences that resulted in higher average posterior shear were those that required outside scanning in unique situations. This was expected because this type of

body posture results in the largest portion of the vertical force of gravity acting in the direction of the posterior/anterior axis.

4.3 MFTA/PDA Integration

The MFTA/PDA was integrated into a relational database that linked the Mission Task Library to postural sequences in the PDA library. Using this relational database, individual mission task segments could then be pieced together using the Mission Builder, to create an infinite number of customizable composite missions. Based on this approach, the pattern and profile of various neck strain measures can be tracked over time to identify peak neck strain and the cumulative exposure of these measures over the course of a mission, training mission or across several missions (Figure 21). This approach forms the final output of the Integrated MFTA PDA Model (IMPM), and is described in more detail below.

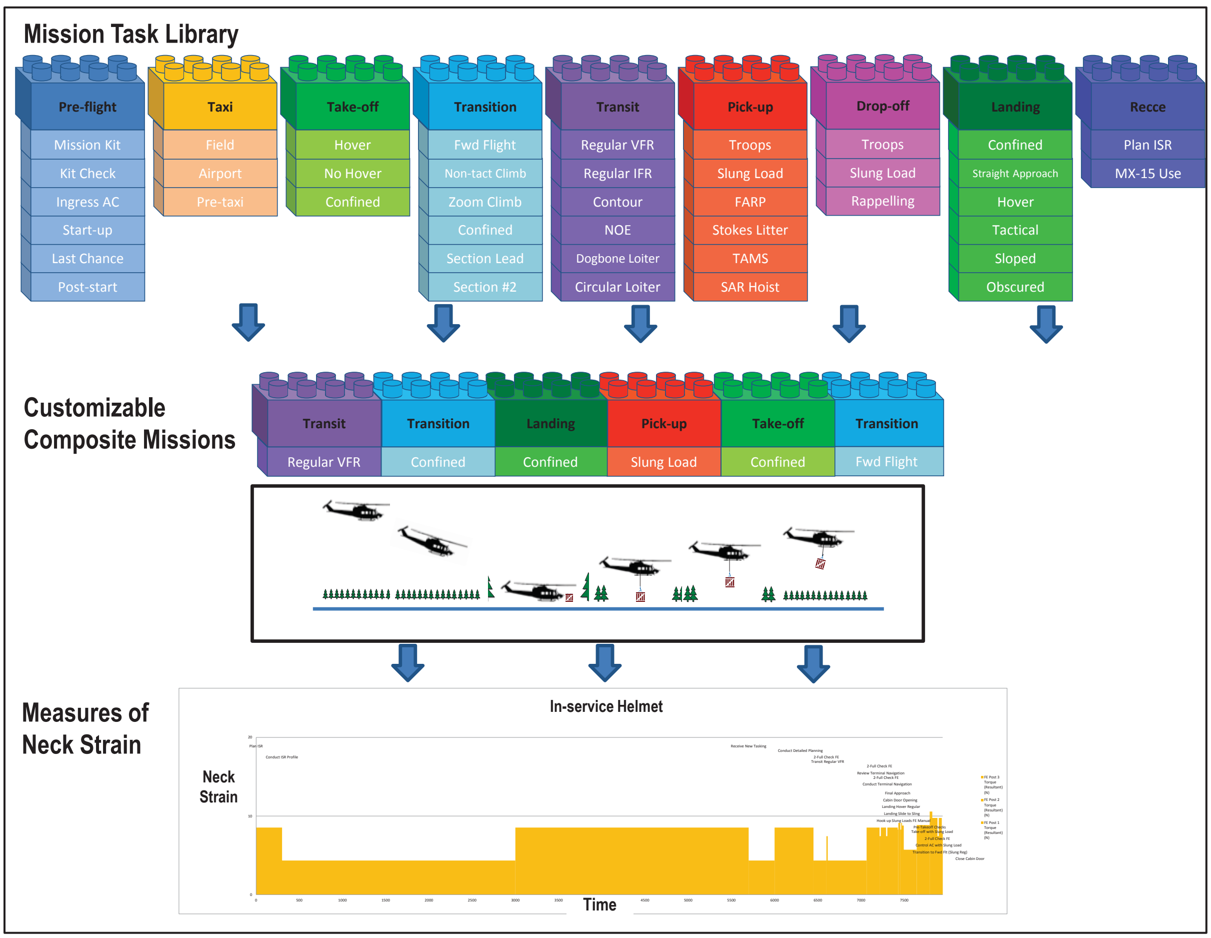

Figure 21: MFTA/PDA Integration

The Mission Task Library consisted of the 21 mission blocks (represented as level 1 large blocks) as previously defined (Table 5), and the 95 mission tasks (represented as the level 2 half-blocks) (Table 6). It should be noted that only nine of the 21 mission blocks and 41 of the 95 mission tasks are presented in this figure for sake of graphic clarity. Furthermore, the 69 mission sub tasks (Table 7) comprise the 3rd level and were distributed within the level 2 half-blocks or mission tasks (mission sub-tasks are not shown). The centre of Figure 21 depicts the assembly of the mission blocks and mission task segments into a composite mission using the Mission Builder. The postural sequences within the Mission Builder were then linked to the measures of neck strain (i.e. Compression, Tension, Anterior Shear, Posterior Shear, Right Lateral Shear, Left Lateral Shear, and Resultant Torque) from the PDA library (Figure 22), so that the pattern and profile of neck strain could be modeled and tracked over the course of the mission and output graphically. A sample graph is shown at the bottom of Figure 21.

Mission Block	Mission Task	Duration (sec)	FP Postural Seq.	% Dur.	FP Compression (N)	FP Tension (N)	FP Ant. Shear (N)	FP Post. Shear (N)	FP R. Lat. Shear (N)	FP L. Lat. Shear (N)	FP Torque (Resultant) (Nm)	NFP Postural Seq.	% Dur.	NFP Compression (N)	NFP Tension (N)	NFP Ant. Shear (N)	NFP Post. Shear (N)	NFP R. Lat. Shear (N)	NFP L. Lat. Shear (N)	NFP Torque (Resultant) (Nm)	FE Postural Seg.	% Dur.	FE Compression (N)	FE Tension (N)	FE Ant. Shear (N)	FE Post. Shear (N)	FE R. Lat. Shear (N)	FE L. Lat. Shear (N)	FE Torque (Resultant) (Nm)
PRE-FLIGHT	Load Mission Kit	600	Walking	100	58.73	NA	9.62	-12.72	6.14	-6.35	3.91	Walking	100	58.73	NA	9.62	-12.72	6.14	-6.35	3.91	Walking	80	58.80	NA	11.26	-13.16	8.52	-9.48	3.92
	Open and Ingress AC	300	AC Ingress	100	56.87	-8.75	9.08	-12.74	8.90	-8.75	6.22	AC Ingress	100	55.59	-3.86	7.74	-16.04	9.08	-10.56	6.09	Door Opening Outside	100	58.31	NA	7.09	-11.32	6.30	-8.64	4.46
	Start-up/Last Chance Insp.	600	Outside Scan Regular	25	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	20	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Start-up/Last Chance Insp.	100	55.09	-4.31	7.69	-16.69	12.10	-12.02	4.45
	Post-start Checks	60	Outside Scan Regular	50	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	20	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Equipment Handling Inside	100	27.05	-2.65	17.33	-47.05	13.48	-18.79	8.50
	Mission Kit Check (Hook)	120	Inside Scan Dash Gauges	100	58.72	NA	6.87	-2.16	6.17	-2.26	4.40	Inside Scan Dash Gauges	100	57.31	NA	6.62	-5.12	2.84	-11.79	5.14	Sling Hook-up Manual	100	44.49	-7.75	28.58	-30.62	17.32	-16.26	7.26
TAXI	Pre-taxi Checks	25	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Inside Scan Dash Gauges	50	57.31	NA	6.62	-5.12	2.84	-11.79	5.14	Scan Seated Door Closed	100	55.51	NA	2.80	-14.72	4.15	-9.87	5.90
	Taxi Field	60	Outside Scan Regular	85	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Regular Take-off	100	46.75	NA	3.91	-32.51	7.44	-11.66	6.24
TAKE-OFF	Pre-Takeoff Checks	30	Inside Scan Dash Gauges	95	58.72	NA	6.87	-2.16	6.17	-2.26	4.40	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Equipment Handling Inside	100	27.05	-2.65	17.33	-47.05	13.48	-18.79	8.50
	Take-off to Hover Regular	20	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Regular Take-off	100	46.75	NA	3.91	-32.51	7.44	-11.66	6.24
	Pre-departure Checks	60	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Troops on Sill	100	25.39	NA	1.97	-48.42	12.87	-16.20	7.81
	2-Full Check FE	15	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	2-Full Check	100	54.20	NA	9.38	-19.97	8.44	-9.37	4.60
TRANSITION	Transition to Forward Flt (Reg)	10	Outside Scan Regular	90	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	60	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Regular Take-off	100	46.75	NA	3.91	-32.51	7.44	-11.66	6.24
	Close Cabin Door	10	Outside Scan Regular	90	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Door Closing Seated	100	54.54	NA	11.08	-20.86	13.63	-10.45	6.16
TRANSIT	Transit Regular VFR	300	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	80	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Transit Seated	75	58.63	NA	5.02	-9.37	2.56	-3.07	2.58
LAND	Review Terminal Navigation	60	Outside Scan Regular	90	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	40	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Seated Door Closed	100	55.51	NA	2.80	-14.72	4.15	-9.87	5.90
	2-Full Check FE	15	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	2-Full Check	100	54.20	NA	9.38	-19.97	8.44	-9.37	4.60
	Conduct Terminal Navigation	120	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	80	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Seated Door Closed	100	55.51	NA	2.80	-14.72	4.15	-9.87	5.90
	Final Approach	30	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Door Opening Inside	25	51.73	NA	8.63	-24.03	11.11	-16.79	5.96
	Cabin Door Opening	10	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Door Opening Inside	100	51.73	NA	8.63	-24.03	11.11	-16.79	5.96
	Landing Hover Regular	10	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Regular Landing	100	45.78	NA	NA	-34.74	10.13	-11.31	6.95
	Landing Slide to Sling	20	Outside Scan Regular	100	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	90	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan during Slide to Sling	100	29.29	-19.48	13.54	-41.06	15.13	-26.11	7.59
PICK-UP	Hook up Slung Loads FE Manual	300	Outside Scan Regular	100	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	90	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Walking	50	58.80	NA	11.26	-13.16	8.52	-9.48	3.92
TAKE-OFF	Pre-Takeoff Checks	30	Inside Scan Dash Gauges	95	58.72	NA	6.87	-2.16	6.17	-2.26	4.40	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Equipment Handling Inside	100	27.05	-2.65	17.33	-47.05	13.48	-18.79	8.50
	Take-off with Slung Load	60	Outside Scan Regular	100	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Slung Load	100	31.21	-0.77	NA	-43.42	10.94	-17.40	7.86
	2-Full Check FE	15	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	2-Full Check	100	54.20	NA	9.38	-19.97	8.44	-9.37	4.60
	Control AC with Slung Load	15	Outside Scan Regular	100	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	10	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Slung Load	100	31.21	-0.77	NA	-43.42	10.94	-17.40	7.86
TRANSITION	Transition to Fwd Flt (Slung Reg)	20	Outside Scan Regular	90	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	60	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Slung Load	100	31.21	-0.77	NA	-43.42	10.94	-17.40	7.86
	Close Cabin Door	10	Outside Scan Regular	90	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Door Closing Seated	100	54.54	NA	11.08	-20.86	13.63	-10.45	6.16
	Non-tactical Climb	180	Outside Scan Regular	80	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	70	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Seated Door Closed	100	55.51	NA	2.80	-14.72	4.15	-9.87	5.90
TRANSIT	Transit with Slung Load	300	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Slung Load	20	31.21	-0.77	NA	-43.42	10.94	-17.40	7.86
LAND	Review Terminal Navigation	60	Outside Scan Regular	90	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	40	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Seated Door Closed	100	55.51	NA	2.80	-14.72	4.15	-9.87	5.90
	2-Full Check FE	15	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	2-Full Check	100	54.20	NA	9.38	-19.97	8.44	-9.37	4.60
	Conduct Terminal Navigation	120	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	80	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Seated Door Closed	100	55.51	NA	2.80	-14.72	4.15	-9.87	5.90
	Final Approach	30	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Door Opening Inside	25	51.73	NA	8.63	-24.03	11.11	-16.79	5.96
	Cabin Door Opening	10	Outside Scan Regular	95	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Door Opening Inside	100	51.73	NA	8.63	-24.03	11.11	-16.79	5.96
DROP-OFF	Slung Load Landing	300	Outside Scan Regular	99	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	90	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Scan Slung Load	100	31.21	-0.77	NA	-43.42	10.94	-17.40	7.86
DROP-OFF	Slung Load Unhook Manual	60	Outside Scan Regular	90	59.19	NA	4.10	-2.09	2.47	-1.57	3.48	Outside Scan Regular	50	58.79	NA	4.50	-6.07	3.52	-5.50	3.53	Sling Unhook Manual	100	37.45	-5.26	38.36	-29.79	22.58	-19.46	7.25

Figure 22: Mission Builder (sample output)

4.3.1 PDA and Mission Builder

Using the Mission Builder, two vignettes were created and the pattern and profile of neck Compression, Tension, Anterior Shear, Posterior Shear, Right Lateral Shear, Left Lateral Shear, and Resultant Torque measures were tracked against time to identify the cumulative exposure of these measures over a day and night missions for each vignette:

Vignette 1 – Logistics Support and Surveillance Mission

Vignette 2 – Slung Load Training Mission

The results of these analyses for each of these vignettes are discussed in more detail below.

4.3.1.1 Vignette 1 – Logistics Support and Surveillance Mission

This mission includes a sequence of logistic and surveillance mission components that would be typical of a 5.5 hour mission in Afghanistan. The mission begins with pre-flight checks, then loads and transports troops to a forward operating base, then transits to an overwatch location to perform surveillance, then transits to a Forward Area Re-fueling/Re-arming Point (FARP) to re-fuel, then picks up a slung load and returns to base, and performs post-mission tasks.

This mission consisted of 33 Mission Blocks, and 93 Mission Tasks for a total mission time of 19915 seconds for the day (5 hours, 31 minutes, 55 seconds) and 21128 seconds (5 hours, 52 minutes, 8 seconds) for the night (Table 19). During the course of this mission, six unique postural sequences were adopted by the FP, ten by the NFP, and 19 by the FE (Table 20).

Table 19: Vignette 1 – Logistics Support and Surveillance Mission

Mission Block	Mission Task	Mission Block (cont.)	Mission Task	Mission Block (cont.)	Mission Task
PRE-FLIGHT	Load Mission Kit		Close Cabin Door		2-Full Check FE
	Open and Ingress AC		Transition to Sect. Mov't Lead		Conduct Terminal Navigation
	Start-up/Last Chance Insp.		Zoom Climb		Final Approach
	Post-start Checks	TRANSIT	Transit Regular VFR		Cabin Door Opening
	Mission Kit Check (Hook)	RECCE	Plan ISR		Landing Hover Regular
LOAD	Troops		Conduct ISR Profile		Landing Slide to Sling
	Secure Troops/Equip in AC	RETASKING	Receive New Tasking	PICK-UP	Hook up Slung Loads FE Manual
TAXI	Pre-taxi Checks		Conduct Detailed Planning	TAKE-OFF	Pre-Takeoff Checks
TAXI	Taxi Field		2-Full Check FE		Take-off with Slung Load
TAKE-OFF	Pre-Takeoff Checks	TRANSIT	Transit Regular VFR		2-Full Check FE

	Take-off to Hover Regular		2-Full Check FE		Control AC with Slung Load
	Pre-departure Checks	LAND	Review Terminal Navigation	TRANSITION	Transition to Fwd Flt (Slung Reg)
	2-Full Check FE		2-Full Check NFP Pilot		Close Cabin Door
TRANSITION	Transition to Forward Flt (Reg)		Conduct Terminal Navigation		Transition to Sect. Mov't Lead
	Close Cabin Door		Final Approach		Non-tactical Climb
	Transition to Sect. Mov't Lead		Cabin Door Opening	TRANSIT	Transit with Slung Load
	Non-tactical Climb		Landing Hover Confined	LAND	Review Terminal Navigation
TRANSIT	Transit Contour	PICK-UP	FARP Pick-up		2-Full Check FE
	2-Full Check NFP Pilot		Post-start Checks		Conduct Terminal Navigation
NAV/COMMS	Enroute Navigation	TAKE-OFF	Pre-departure Checks		Final Approach
LAND	Review Terminal Navigation		Pre-Takeoff Checks		Cabin Door Opening
	2-Full Check NFP Pilot		2-Full Check FE	DROP-OFF	Slung Load Landing
	Conduct Terminal Navigation		Take-off Confined Area		Slung Load Unhook Manual
	Final Approach	TRANSITION	Transition to Forward Flt (Reg)	TAKE-OFF	Pre-Takeoff Checks
	Cabin Door Opening		Close Cabin Door		Take-off to Hover Regular
	Landing Tactical Regular		Transition to Sect. Mov't Lead		2-Full Check FE
DROP-OFF	Troops		Non-tactical Climb to Contour	TAXI	Taxi Field
TAKE-OFF	Pre-Takeoff Checks	TRANSIT	Transit Contour	LAND	Landing Hover Regular
	Take-off No Hover Regular		2-Full Check NFP Pilot	SHUTDOWN	Post-landing Shutdown
TRANSITION	Transition to Fwd Flt (Zoom)	NAV/COMMS	Enroute Navigation		Close Cabin Door
	2-Full Check NFP Pilot	LAND	Review Terminal Navigation		Egress AC

Table 20: Vignette 1 – Postural Sequence

FP Postural Sequence	NFP Postural Sequence	FE Postural Sequence
Walking	Walking	Walking
AC Ingress	AC Ingress	Door Opening Outside
Outside Scan Regular	Outside Scan Regular	Start-up/Last Chance Insp.
Inside Scan Dash Gauges	Inside Scan Dash Gauges	Equipment Handling Inside
Outside Scan Confined	Outside Scan Confined	Sling Hook-up Manual
AC Egress	AC Egress	Scan Seated Door Closed
	Map/Doc Referencing	Scan Regular Take-off
	CDU/AMS Use	Scan Troops on Sill
	Inside Scan Ceiling Switches	2-Full Check
	MX-15 Use	Door Closing Seated
		Transit Seated
		Door Opening Inside
		Scan Confined
		Scan Regular Landing
		Scan during Slide to Sling
		Scan Slung Load
		Sling Unhook Manual
		Door Closing Outside
		Equipment Handling Outside

4.3.1.1.1 Cumulative Mission Demands – Logistics Support and Surveillance Mission

Results from this analysis showed that overall cumulative loads were higher for the night vs. day mission, with the exception of anterior, posterior, and left lateral shear for the FP (Table 21).

Table 21: Vignette 1 – Cumulative Neck Strain Load

		FP		NFP		FE	
Measures of Neck Strain	**Unit**	**Day**	**Night**	**Day**	**Night**	**Day**	**Night**
Cumulative Loads							
Compression	Ns	1176107.9	1586361.0	1132461.5	1568735.4	1058993.9	1395835.9
Tension	Ns	-2626.4	-4229.8	-1159.0	-2575.1	-10198.3	-12506.7
Anterior Shear	Ns	95418.1	94241.8	81736.3	106019.5	103504.4	183030.7
Posterior Shear	Ns	-53116.6	-51961.8	-139218.9	-174711.4	-361642.8	-476633.4
Right Lateral Shear	Ns	65030.0	112199.4	66427.4	79312.7	118871.5	195514.7
Left Lateral Shear	Ns	-39608.0	-37928.1	-248155.9	-321366.8	-180850.9	-308895.1
Torque (Resultant)	Nms	73449.1	86170.5	105601.6	113442.7	100806.1	128490.5

The greatest increase in magnitude from day to night for neck compression and tension was observed in the NFP (138% and 222 respectively), the greatest increase in magnitude for right lateral shear was observed in the FP (172%), while the greatest increase in magnitude for the other measures of neck strain were observed for the FE; 177% for anterior shear, 132% for posterior shear, 171% for left lateral shear, and 128% for resultant torque.

Between all three aircrew roles for the day mission, the largest cumulative load for compression (1176107.9 Ns) was experienced by the FP, the largest cumulative load for left lateral shear (-248155.9 Ns) and torque (105601.6 Nms) was experienced by the NFP, and the largest cumulative load for tension (-10198.3 Ns), anterior shear (103504.4 Ns), posterior shear (-361642.8 Ns), and right lateral shear (118871.5 Ns) was experienced by the FE. During the night mission, the largest cumulative load for compression (1586361.0 Ns) was experienced by the FP, the largest cumulative load for left lateral shear (-321366.8 Ns) was experienced by the NFP, and the largest cumulative load for tension (-12506.7 Ns), anterior shear (183030.7 Ns), posterior shear (-476633.4 Ns), right lateral shear (195514.7 Ns) and resultant torque (128490.5 Nms) was experienced by the FE.

The postural sequence that occurred most frequently was Outside Scan Regular (88) for the FP for a total duration of 15720.5 seconds (262.0 minutes) or 79% of the entire mission duration for the day, and 16293.8 seconds (271.6 minutes) or 77% of the entire mission duration for the night. The second most frequently occurring postural sequence was Inside Scan Dash Gauges (86) for a total duration of 3006.5 seconds (50.1 minutes) for the day, and 3166.3 seconds (52.8 minutes) for the night.

For the NFP the postural sequence that occurred most frequently was Outside Scan Regular (81) for a total duration of 8302.0 seconds (138.4 minutes) for the day, and 8775.1 seconds (146.3 minutes) for the night. The second most frequently occurring postural sequence was Inside Scan Dash Gauges (70) for a total duration of 2611.0 seconds (43.5 minutes) for the day, and 2677.8 seconds (44.6 minutes) for the night. Although MX-15 Use occurred only once, it was the postural sequence that required the second longest duration for the NFP, 4050.0 seconds (67.5 minutes) for the day, and 4050.0 seconds for the night. This postural sequence represented 20% of the entire day mission, and 19% of the entire night mission.

For the FE the postural sequence that occurred most frequently was Scan Seated Door Closed (33) for a total duration of 7570.0 seconds (126.2 minutes) or 38% of the entire mission duration for the day, and 7590.0 seconds (126.5 minutes) or 36% of the entire mission duration for the night. The second most frequently occurring postural sequence was Equipment Handling Inside (10) for a total duration of 558.0 seconds (9.3 minutes) for the day and 651.0 seconds (10.8 minutes) for the night. Although Transit Seated occurred only seven times, it was the postural sequence that required the second longest duration for the FE, 5400.0 seconds (90 minutes) for the day and night. This postural sequence represented 27% of the entire day mission, and 26% of the entire night mission.

Resultant Torque Threshold - Logistics Support and Surveillance Mission

In order to identify the aircrew roles and tasks with the highest resultant torque values, a threshold was arbitrarily defined based on a factor of two times the magnitude of the resultant torque for walking (day). This threshold of 7.8 Nm was the same for the FP, NFP, and FE. Sample resultant torque graphs are shown for the Flight Engineer (Figure 23 and Figure 24). For all aircrew roles, see Annex D: Summary Cumulative Mission Results – Resultant Torque.

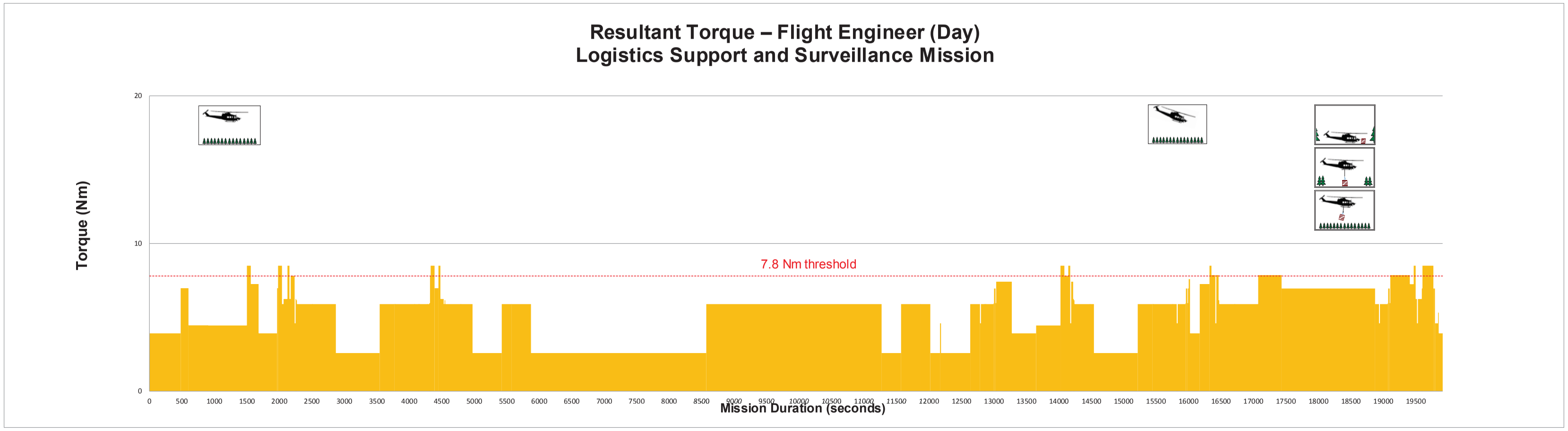

Figure 23: Resultant Torque – Flight Engineer (Day) Logistics Support and Surveillance Mission

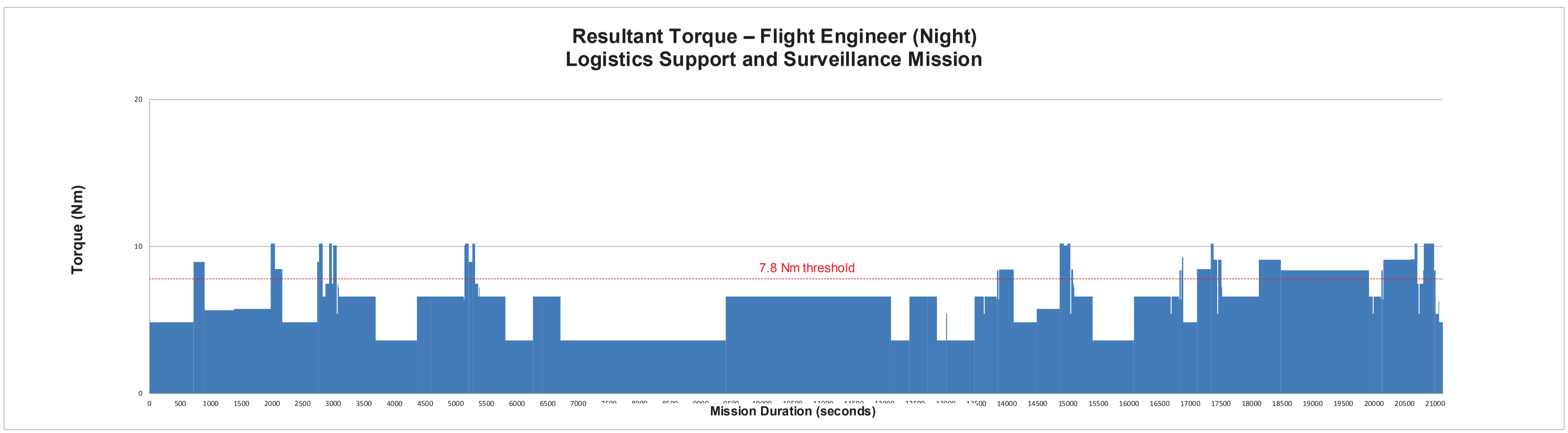

Figure 24: Resultant Torque – Flight Engineer (Night) Logistics Support and Surveillance Mission

For the FP, this threshold was exceeded for two postural sequences; AC Ingress which was adopted during the Open and Ingress AC Mission Task, and AC Egress which was adopted during the Egress AC Mission Task. The average resultant torque for AC Ingress was 8.23 Nm, and was sustained for 480 seconds (8 minutes), and the average resultant torque for AC Egress was 7.84 Nm, and was sustained for 60 seconds (1 minute). This threshold was exceeded only during the night mission (Table 22).

Table 22: Logistics Support and Surveillance Mission – FP Exceeding 7.8 Nm Threshold

Day/ Night	Mission Task	Postural Sequence	Duration (sec)	Resultant Torque (Nm)
Day	n/a	n/a	n/a	n/a
Night	Open and Ingress AC	AC Ingress	480	8.23
	Egress AC	AC Egress	60	7.84

For the NFP, this threshold was exceeded for two postural sequences; MX-15 Use (day) which was adopted during the Conduct ISR Profile Mission Task, and AC Egress (night) which was adopted during the Egress AC Mission Task. The average resultant torque for MX-15 Use was 8.06 Nm, and was sustained for 4050 seconds (67.5 minutes), and the average resultant torque for AC Egress was 8.19 Nm, and was sustained for 60 seconds (1 minute) (Table 23).

Table 23: Logistics Support and Surveillance Mission – NFP Exceeding 7.8 Nm Threshold

Day/ Night	Mission Task	Postural Sequence	Duration (sec)	Resultant Torque (Nm)
Day	Conduct ISR Profile	MX-15 Use	4050	8.06
Night	Egress AC	AC Egress	60	8.19

For the FE during the day mission, this threshold was exceeded for three postural sequences that were adopted during 12 Mission Tasks as listed in Table 24. The highest average resultant torque (8.50 Nm) was for Equipment Handling Inside the cabin and, in total, the FE exceeded the 7.8 Nm resultant torque threshold for 1443 seconds (24 minutes) over the course of the entire mission.

During the night mission, the 7.8 Nm threshold was exceeded for nine postural sequences that were adopted during 21 Mission Tasks as listed in Table 24. Similar to the day mission, the highest average resultant torque (10.2 Nm) was for Equipment Handling Inside the cabin. In total, the FE exceeded the 7.8 Nm resultant torque threshold for 4223 seconds (70.4 minutes) over the course of the entire mission.

Results from this mission show that both the NFP and FE are required to sustain neck postures that exceed this 7.8 Nm threshold for well over an hour. In the case of the NFP during the day mission, a single postural sequence (consulting the MX-15) exceeded this threshold for 67.5 minutes. Therefore this preliminary analysis shows that MX-15 use is potentially the most strenuous task related to neck

strain, which is supported by the concerns that were raised by the SMEs. Conversely for the FE, a combination of several postural sequences exceeded the 7.8 Nm threshold for a total time of 70.4 minutes. This is also consistent with SME comments that indicated FEs are required to adopt and sustain the most strenuous combination of postural sequences in order to carry out their duties, which was perceived to be worse at night.

Table 24: Logistics Support and Surveillance Mission – FE Exceeding 7.8 Nm Threshold

Day/ Night	Mission Task	Postural Sequence	Duration (sec)	Resultant Torque (Nm)
Day	Post-landing Shutdown	Equipment Handling Inside	168	8.50
	Post-start Checks	Equipment Handling Inside	120	8.50
	Pre-Takeoff Checks	Equipment Handling Inside	150	8.50
	Secure Troops/Equip in AC	Equipment Handling Inside	60	8.50
	Troops	Equipment Handling Inside	60	8.50
	Control AC with Slung Load	Scan Slung Load	15	7.86
	Slung Load Landing	Scan Slung Load	300	7.86
	Take-off with Slung Load	Scan Slung Load	60	7.86
	Transit with Slung Load	Scan Slung Load	360	7.86
	Transition to Fwd Flt (Slung Reg)	Scan Slung Load	20	7.86
	Landing Tactical Regular	Scan Troops on Sill	10	7.81
	Pre-departure Checks	Scan Troops on Sill	120	7.81
Night	Post-landing Shutdown	Equipment Handling Inside	168	10.2
	Post-start Checks	Equipment Handling Inside	138	10.2
	Pre-Takeoff Checks	Equipment Handling Inside	225	10.2
	Secure Troops/Equip in AC	Equipment Handling Inside	60	10.2
	Troops	Equipment Handling Inside	60	10.2
	Landing Tactical Regular	Scan Troops on Sill	10	10.07
	Pre-departure Checks	Scan Troops on Sill	120	10.07
	Landing Slide to Sling	Scan during Slide to Sling	20	9.25
	Slung Load Unhook Manual	Sling Unhook Manual	60	9.13
	Control AC with Slung Load	Scan Slung Load	15	9.1
	Slung Load Landing	Scan Slung Load	450	9.1
	Take-off with Slung Load	Scan Slung Load	60	9.1
	Transit with Slung Load	Scan Slung Load	360	9.1
	Transition to Fwd Flt (Slung Reg)	Scan Slung Load	40	9.1
	Load Mission Kit	Equipment Handling Outside	180	8.95
	Troops	Equipment Handling Outside	90	8.95
	Mission Kit Check (Hook)	Sling Hook-up Manual	120	8.46
	Hook up Slung Loads FE Manual	Sling Hook-up Manual	225	8.46
	Landing Hover Confined	Scan Confined	240	8.44
	Take-off Confined Area	Scan Confined	30	8.44
	Final Approach	Scan Regular Landing	68	8.38
	Landing Hover Regular	Scan Regular Landing	20	8.38
	Post-landing Shutdown	Scan Regular Landing	24	8.38
	Transit with Slung Load	Scan Regular Landing	1440	8.38

4.3.1.2 Vignette 2 – Slung Load Training Mission

This mission represents a 2.5 hour training mission that is typical of the Basic Flight Engineer Course (BFEC). The mission includes typical pre-flight tasks, then performs three cycles of a slung load task sequence (i.e. land and pick-up a slung load, take off, transit a short distance, land, drop off the load, take off, and repeat twice), then a return to base, and perform post-flight tasks.

This mission consisted of 37 Mission Blocks, and 105 Mission Tasks for a total mission time of 8915 seconds for the day (2 hours, 28 minutes, 35 seconds) and 10489 seconds (2 hours, 54 minutes, 49 seconds) for the night (Table 25). During the course of this mission, five unique postural sequences were adopted by the FP, eight by the NFP, and 18 by the FE (Table 26).

Table 25: Vignette 2 – Slung Load Training Mission

Mission Block	Mission Task	Mission Block (cont.)	Mission Task	Mission Block (cont.)	Mission Task
PRE-FLIGHT	Load Mission Kit	DROP-OFF	Slung Load Landing	TRANSITION	Transition to Forward Flt (Reg)
	Open and Ingress AC		Slung Load Unhook Manual		Close Cabin Door
	Start-up/Last Chance Insp.	TAKE-OFF	Pre-Takeoff Checks	TRANSIT	Transit Regular VFR
	Post-start Checks		Take-off to Hover Regular	LAND	Review Terminal Navigation
	Mission Kit Check (Hook)		Pre-departure Checks		2-Full Check FE
TAXI	Pre-taxi Checks		2-Full Check FE		Conduct Terminal Navigation
TAXI	Taxi Field	TRANSITION	Transition to Forward Flt (Reg)		Final Approach
TAKE-OFF	Pre-Takeoff Checks		Close Cabin Door		Cabin Door Opening
	Take-off to Hover Regular	TRANSIT	Transit Regular VFR		Landing Hover Regular
	Pre-departure Checks	LAND	Review Terminal Navigation		Landing Slide to Sling
	2-Full Check FE		2-Full Check FE	PICK-UP	Hook up Slung Loads FE Manual
TRANSITION	Transition to Forward Flt (Reg)		Conduct Terminal Navigation	TAKE-OFF	Pre-Takeoff Checks
	Close Cabin Door		Final Approach		Take-off with Slung Load
TRANSIT	Transit Regular VFR		Cabin Door Opening		2-Full Check FE
LAND	Review Terminal Navigation		Landing Hover Regular		Control AC with Slung Load
	2-Full Check FE		Landing Slide to Sling	TRANSITION	Transition to Fwd Flt (Slung Reg)
	Conduct Terminal	PICK-UP	Hook up Slung Loads		Close Cabin Door

	Navigation		FE Manual		
	Final Approach	TAKE-OFF	Pre-Takeoff Checks		Non-tactical Climb
	Cabin Door Opening		Take-off with Slung Load	TRANSIT	Transit with Slung Load
	Landing Hover Regular		2-Full Check FE	LAND	Review Terminal Navigation
	Landing Slide to Sling		Control AC with Slung Load		2-Full Check FE
PICK-UP	Hook up Slung Loads FE Manual	TRANSITION	Transition to Fwd Flt (Slung Reg)		Conduct Terminal Navigation
TAKE-OFF	Pre-Takeoff Checks		Close Cabin Door		Final Approach
	Take-off with Slung Load		Non-tactical Climb		Cabin Door Opening
	2-Full Check FE	TRANSIT	Transit with Slung Load	DROP-OFF	Slung Load Landing
	Control AC with Slung Load	LAND	Review Terminal Navigation		Slung Load Unhook Manual
TRANSITION	Transition to Fwd Flt (Slung Reg)		2-Full Check FE	TAKE-OFF	Pre-Takeoff Checks
	Close Cabin Door		Conduct Terminal Navigation		Take-off to Hover Regular
	Non-tactical Climb		Final Approach		2-Full Check FE
TRANSIT	Transit with Slung Load		Cabin Door Opening	TAXI	Taxi Field
LAND	Review Terminal Navigation	DROP-OFF	Slung Load Landing	LAND	Landing Hover Regular
	2-Full Check FE		Slung Load Unhook Manual	SHUTDOWN	Post-landing Shutdown
	Conduct Terminal Navigation	TAKE-OFF	Pre-Takeoff Checks		Close Cabin Door
	Final Approach		Take-off to Hover Regular		Egress AC
	Cabin Door Opening		Pre-departure Checks		
			2-Full Check FE		

Table 26: Vignette 2 – Postural Sequence

FP Postural Sequence	NFP Postural Sequence	FE Postural Sequence
Walking	Walking	Walking
AC Ingress	AC Ingress	Door Opening Outside
Outside Scan Regular	Outside Scan Regular	Start-up/Last Chance Insp.
Inside Scan Dash Gauges	Inside Scan Dash Gauges	Equipment Handling Inside
AC Egress	AC Egress	Sling Hook-up Manual
	Map/Doc Referencing	Scan Seated Door Closed
	Inside Scan Ceiling Switches	Scan Regular Take-off
	CDU/AMS Use	Scan Troops on Sill
		2-Full Check
		Door Closing Seated
		Transit Seated
		Door Opening Inside
		Scan Regular Landing
		Scan during Slide to Sling
		Scan Slung Load
		Sling Unhook Manual
		Door Closing Outside
		Equipment Handling Outside

4.3.1.2.1 Cumulative Mission Demands – Slung Load Training Mission

Results from this analysis show that overall cumulative loads are higher for the night vs. day mission for all aircrew roles (Table 27).

Table 27: Vignette 2 – Cumulative Neck Strain Load

Measures of Neck Strain	Unit	FP Day	FP Night	NFP Day	NFP Night	FE Day	FE Night
Cumulative Loads							
Compression	Ns	525882.4	786275.5	518125.3	795896.3	425729.9	630026.0
Tension	Ns	-2626.4	-4229.8	-1159.0	-2575.1	-11540.7	-16767.7
Anterior Shear	Ns	45426.7	51541.3	48986.2	62831.9	64234.6	103700.2
Posterior Shear	Ns	-29008.2	-36131.5	-62019.1	-87945.6	-226438.3	-320105.9
Right Lateral Shear	Ns	31701.0	60265.4	35246.3	48208.5	81939.1	130051.3
Left Lateral Shear	Ns	-20479.7	-23918.8	-72007.4	-101879.1	-108283.4	-177022.1
Torque (Resultant)	Nms	33535.1	44349.3	38733.6	48059.3	53232.1	75091.8

The greatest increase in magnitude from day to night for right lateral shear was observed in the FP (190%), the greatest increase in magnitude for neck compression, tension, and posterior shear were observed for the NFP; 154%, 222%, and 142% respectively. The greatest increase in magnitude from day to night for anterior shear, left lateral shear, and resultant torque were for the FE; 161%, 164% and 141% respectively.

Between all three aircrew roles for the day mission, the largest cumulative load for compression (525882.4 Ns) was experienced by the FP, while the largest cumulative loads for the other measures of neck strain were experienced by the FE; tension (-11540.6 Ns), anterior shear (64234.6 Ns), posterior shear (-226438.3 Ns), right lateral shear (81939.1 Ns), left lateral shear (-108283.4 Ns), and torque (53232.1 Nms). During the night mission, the largest cumulative load for compression (795896.3 Ns) was experienced by the NFP, while the largest cumulative load for the other measures of neck strain were experienced by the FE; tension (-16767.7 Ns), anterior shear (103700.2 Ns), posterior shear (-320105.9 Ns), right lateral shear (130051.3 Ns), left lateral shear (-177022.1 Ns), and torque (75091.8 Nms).

The postural sequence that occurred most frequently was Outside Scan Regular (101) for the FP for a total duration of 6562.5 seconds (109.4.5 minutes) or 74% of the entire mission duration for the day, and 7540.8 seconds (125.7 minutes) or 72% of the entire mission duration for the night. The second most frequently occurring postural sequence was Inside Scan Dash Gauges (90) for a total duration of 1392.5 seconds (23.2 minutes) during the day, and 1508.3 seconds (25.1 minutes) for the night.

For the NFP the postural sequence that occurred most frequently was Outside Scan Regular (100) for a total duration of 4900.0 seconds (81.7 minutes) or 55% of the entire mission duration for the day, and 5800.3 seconds (96.7 minutes) or 55% of the entire mission duration for the night. The second most frequently occurring postural sequence was Inside Scan Dash Gauges (94) for a total duration of 2138.0 seconds (35.6 minutes) for the day, and 2288.3 seconds (38.1 minutes) for the night.

For the FE the postural sequence that occurred most frequently was Scan Seated Door Closed (19) for a total duration of 1870.0 seconds (31.2 minutes) or 21% of the entire mission duration for the day, and 1890.0 seconds or 18% of the entire mission duration for the night. The second most frequently occurring postural sequence was Scan Slung Load (15) for a total duration of 1365.0 seconds (22.8 minutes) for the day, and 1875.0 seconds (31.2 minutes) for the night.

Resultant Torque Threshold - Slung Load Training Mission

A 7.8 Nm threshold, based on a factor of two times the magnitude of the resultant torque for walking (day), was also set for this mission to identify the aircrew roles and tasks with the highest resultant torque values. Sample resultant torque graphs are shown for the Flight Engineer (Figure 25 and Figure 26). For all aircrew roles, see Annex D: Summary Cumulative Mission Results – Resultant Torque.

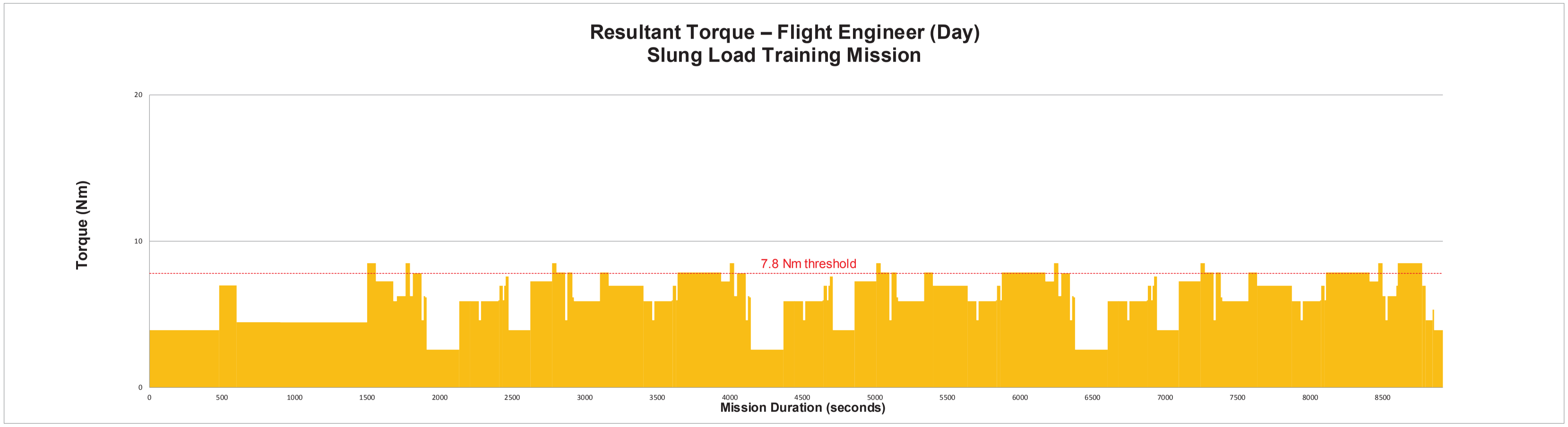

Figure 25: Resultant Torque – Flight Engineer (Day) Slung Load Training Mission

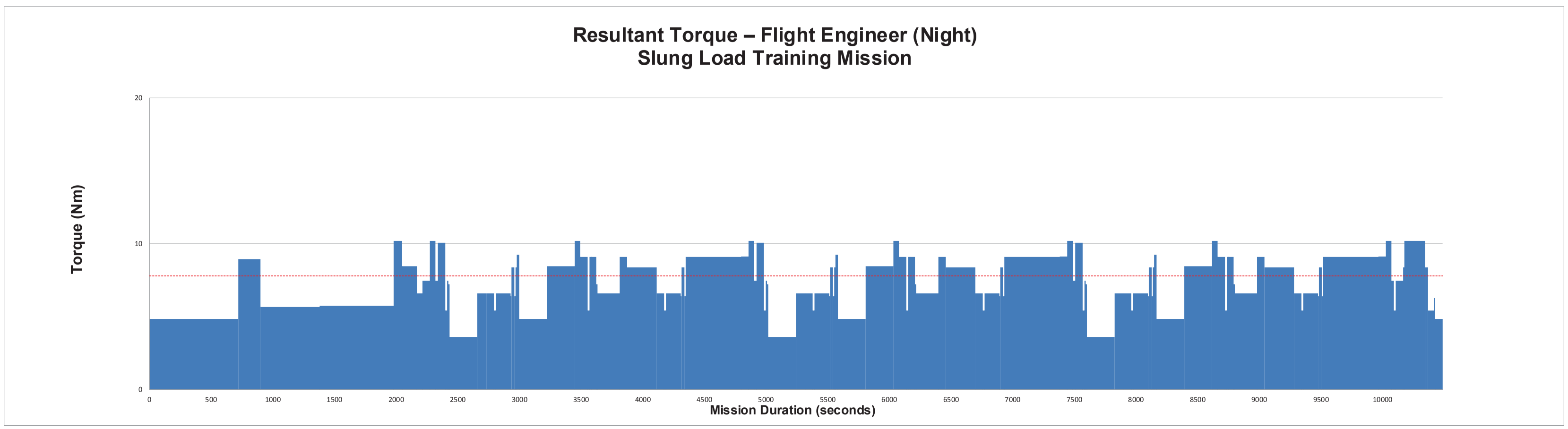

Figure 26: Resultant Torque – Flight Engineer (Night) Slung Load Training Mission

For the FP, similar to the Logistics Support and Surveillance Mission, this threshold was exceeded for two postural sequences; AC Ingress which was adopted during the Open and Ingress AC Mission Task, and AC Egress which was adopted during the Egress AC Mission Task. The average resultant torque for AC Ingress was 8.23 Nm, and was sustained for 480 seconds (8 minutes), and the average resultant torque for AC Egress was 7.84 Nm, and was sustained for 60 seconds (1 minute). This threshold was exceeded only during the night mission (Table 28).

Table 28: Slung Load Training Mission – FP Exceeding 7.8 Nm Threshold

Day/ Night	Mission Task	Postural Sequence	Duration (sec)	Resultant Torque (Nm)
Day	n/a	n/a	n/a	n/a
Night	Open and Ingress AC	AC Ingress	480	8.23
	Egress AC	AC Egress	60	7.84

For the NFP, this threshold was exceeded for only AC Egress (night) which was adopted during the Egress AC Mission Task. The average resultant torque was 8.19 Nm, and was sustained for 60 seconds (1 minute) (Table 29).

Table 29: Slung Load Training Mission – NFP Exceeding 7.8 Nm Threshold

Day/ Night	Mission Task	Postural Sequence	Duration (sec)	Resultant Torque (Nm)
Day	n/a	n/a	n/a	n/a
Night	Egress AC	AC Egress	60	8.19

For the FE during the day mission, this threshold was exceeded for three postural sequences that were adopted during nine Mission Tasks as listed in Table 30. The highest average resultant torque (8.50 Nm) was for Equipment Handling Inside the cabin, and in total, the FE exceeded the 7.8 Nm resultant torque threshold for 1983 seconds (33 minutes) over the course of the entire mission.

During the night mission, the 7.8 Nm threshold was exceeded for eight postural sequences that were adopted during 18 Mission Tasks as listed in Table 30. Similar to the day mission, the highest average resultant torque (10.2 Nm) was for Equipment Handling Inside the cabin. In total, the FE exceeded the 7.8 Nm resultant torque threshold for 4701 seconds (78.4 minutes) over the course of the entire mission.

Results from this training mission show that in particular, the FE are required to sustain neck postures that exceed the 7.8 Nm threshold for prolonged periods. During the day mission, the FE exceeds this threshold for 1/5th (22%) of the entire mission duration, but during the night mission, the FE exceeds this threshold for almost half (45%) of the entire mission duration. These findings support the comments expressed by the SMEs that suggest training is one of the most demanding tasks especially for the Instructor Flight Engineer (IFE). The concern was not only for a single training mission, but also for the frequent and cumulative exposure of adopting strenuous postural sequences. As an IFE, you are required to repeat training missions day after day training new people, adopting awkward

postures and extreme neck movements, while sustaining these postures for prolonged durations during day and night missions.

Table 30: Slung Load Training Mission – FE Exceeding 7.8 Nm Threshold

Day/ Night	Mission Task	Postural Sequence	Duration (sec)	Resultant Torque (Nm)
Day	Post-landing Shutdown	Equipment Handling Inside	168	8.50
	Post-start Checks	Equipment Handling Inside	60	8.50
	Pre-Takeoff Checks	Equipment Handling Inside	210	8.50
	Control AC with Slung Load	Scan Slung Load	45	7.86
	Slung Load Landing	Scan Slung Load	900	7.86
	Take-off with Slung Load	Scan Slung Load	180	7.86
	Transit with Slung Load	Scan Slung Load	180	7.86
	Transition to Fwd Flt (Slung Reg)	Scan Slung Load	60	7.86
	Pre-departure Checks	Scan Troops on Sill	180	7.81
Night	Post-landing Shutdown	Equipment Handling Inside	168	10.2
	Post-start Checks	Equipment Handling Inside	69	10.2
	Pre-Takeoff Checks	Equipment Handling Inside	315	10.2
	Pre-departure Checks	Scan Troops on Sill	180	10.07
	Landing Slide to Sling	Scan during Slide to Sling	20	9.25
	Slung Load Unhook Manual	Sling Unhook Manual	180	9.13
	Control AC with Slung Load	Scan Slung Load	45	9.1
	Slung Load Landing	Scan Slung Load	1350	9.1
	Take-off with Slung Load	Scan Slung Load	180	9.1
	Transit with Slung Load	Scan Slung Load	180	9.1
	Transition to Fwd Flt (Slung Reg)	Scan Slung Load	120	9.1
	Load Mission Kit	Equipment Handling Outside	180	8.95
	Hook up Slung Loads FE Manual	Sling Hook-up Manual	675	8.46
	Mission Kit Check (Hook)	Sling Hook-up Manual	120	8.46
	Final Approach	Scan Regular Landing	135	8.38
	Landing Hover Regular	Scan Regular Landing	40	8.38
	Post-landing Shutdown	Scan Regular Landing	24	8.38
	Transit with Slung Load	Scan Regular Landing	720	8.38

4.3.2 Mission Differences

In order to compare vignette 1 – Logistics Support and Surveillance Mission, and vignette 2 – Training Slung Load Mission, the cumulative neck loads (i.e. dose rate) for both vignettes were normalized to one hour (3600 seconds). This normalized dose rate for neck compression (Figure 27), posterior shear (Figure 28), and torque (Figure 29) are graphed below.

4.3.2.1 Compression

For the FP and NFP, cumulative neck compression was similar between vignette 1 and 2 for the day mission and similar between these two vignettes for the night mission (0 – 2% difference). Between day and night missions, the night was 127% - 131% greater. For the FE, cumulative neck compression for vignette 1 was 111% higher than vignette 2 between the day missions, and 110% more between the night missions. Similar to the FP, and NFP, there was a trend for neck compression to be higher during night missions (124% - 126%) compared to the day missions. Between the aircrew roles, however, the FE tended to experience the lowest level of neck compression when comparing the day and night missions.

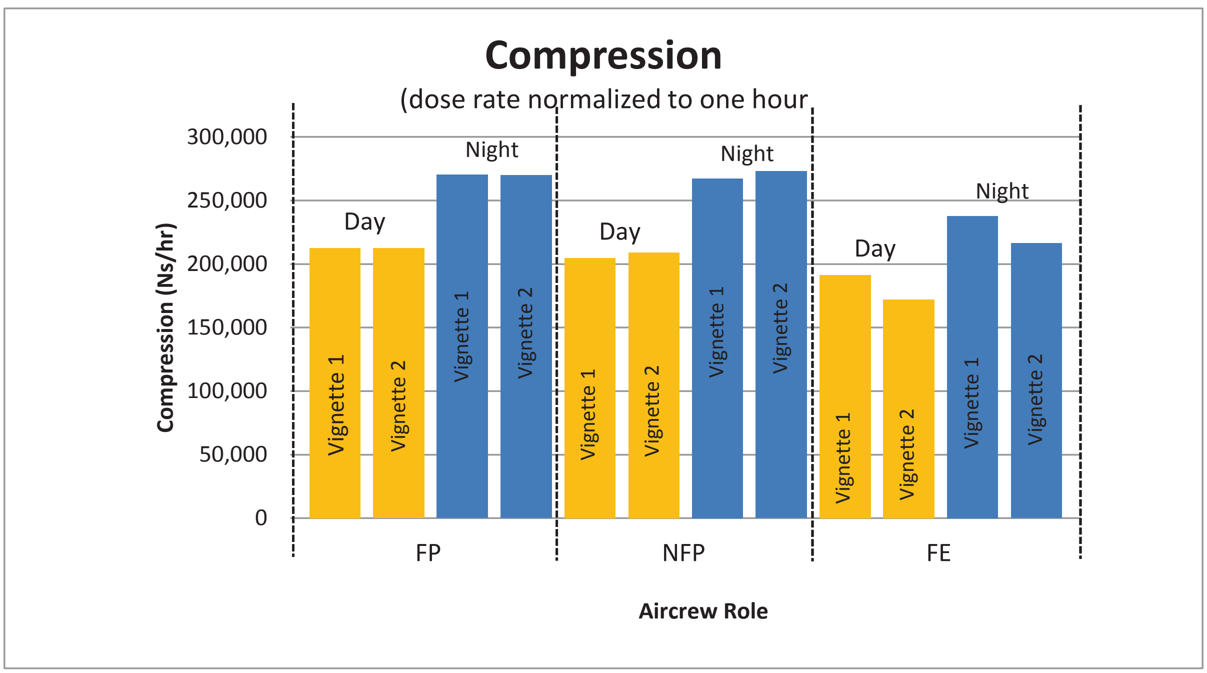

Figure 27: Neck Compression – Hourly Dose rate normalized between missions

4.3.2.2 Posterior Shear

For the FP, cumulative neck posterior shear for vignette 2 was 122% greater than vignette 1 for the day mission and 140% more for the night mission. Between day and night missions, vignette 1 and 2 were similar (92% and 106% respectively).

For the NFP cumulative neck posterior shear was similar between vignette 1 and 2 for the day mission and similar between these two vignettes for the night mission. Between day and night missions, the night was 118% - 121% greater.

For the FE, cumulative neck posterior shear for vignette 2 was 140% greater than vignette 1 for the day mission and 135% more for the night mission. Between day and night missions, the night was 120% - 124% greater.

When comparing between the aircrew roles, however, the FE tended to experience posterior shear values between 681% - 781% greater than the FP for day missions and 886% - 917% greater than the FP during night missions. When compared to the NFP these values were lower, however, the FE still experienced posterior shear values between 260% – 365% greater for day missions and 273% - 364% greater during night mission.

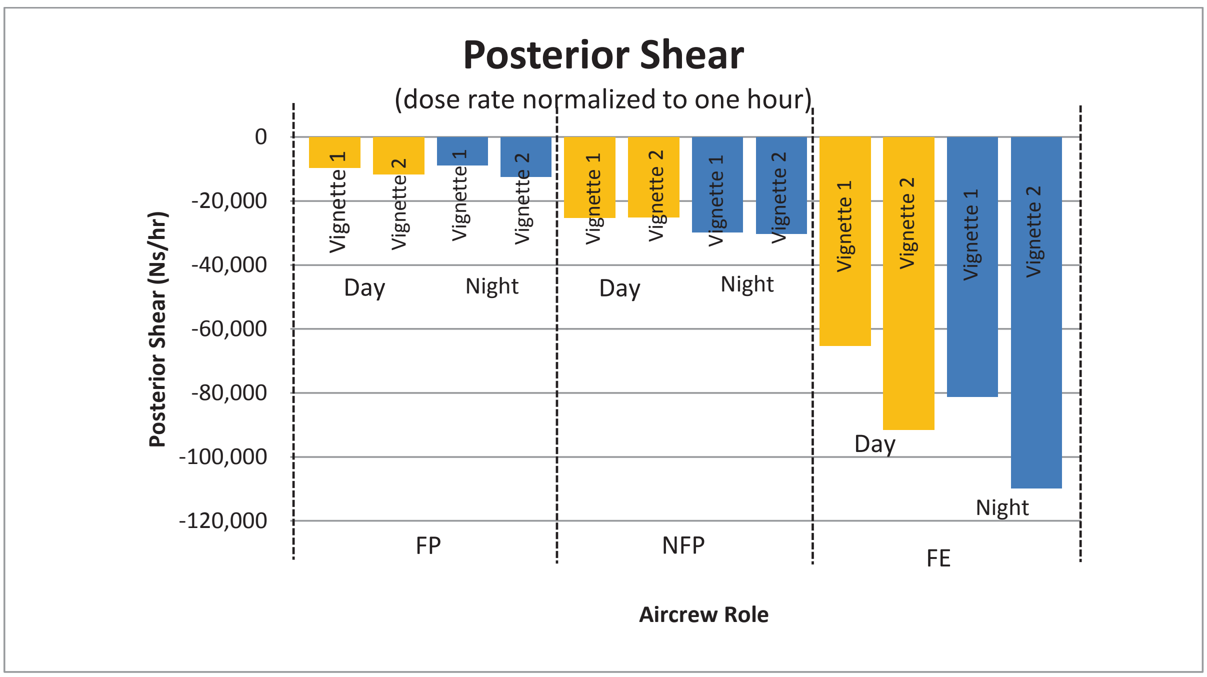

Figure 28: Neck Posterior Shear – Hourly Dose rate normalized between missions

4.3.2.3 Resultant Torque

For the FP, cumulative resultant neck torque was similar between vignette 1 and 2 for the day mission and similar between these two vignettes for the night mission (0 – 4% difference). Between day and night missions, the night was 111% - 112% greater.

For the NFP cumulative resultant neck torque was 122% higher for vignette 1 compared to vignette 2 during the day, and 117% higher during the night. Between day and night missions, the night was only slightly greater (101% - 105%).

For the FE, cumulative resultant neck torque for vignette 2 was 118% greater than vignette 1 for the day mission and 118% more for the night mission. Between day and night missions, the night was 120% greater for both vignette 1 and 2.

When comparing between the aircrew roles, the FE tended to experience resultant torque values between 137% - 159% greater than the FP for day missions and 149% - 169% greater than the FP during night missions. The resultant torque value between the FE and NFP for vignette 1 (day mission) ranged between 95% - 113%, but during vignette 2, the FE tended to experience resultant torque values 137% greater than the NFP for the day mission and 156% greater than the NFP during the night mission.

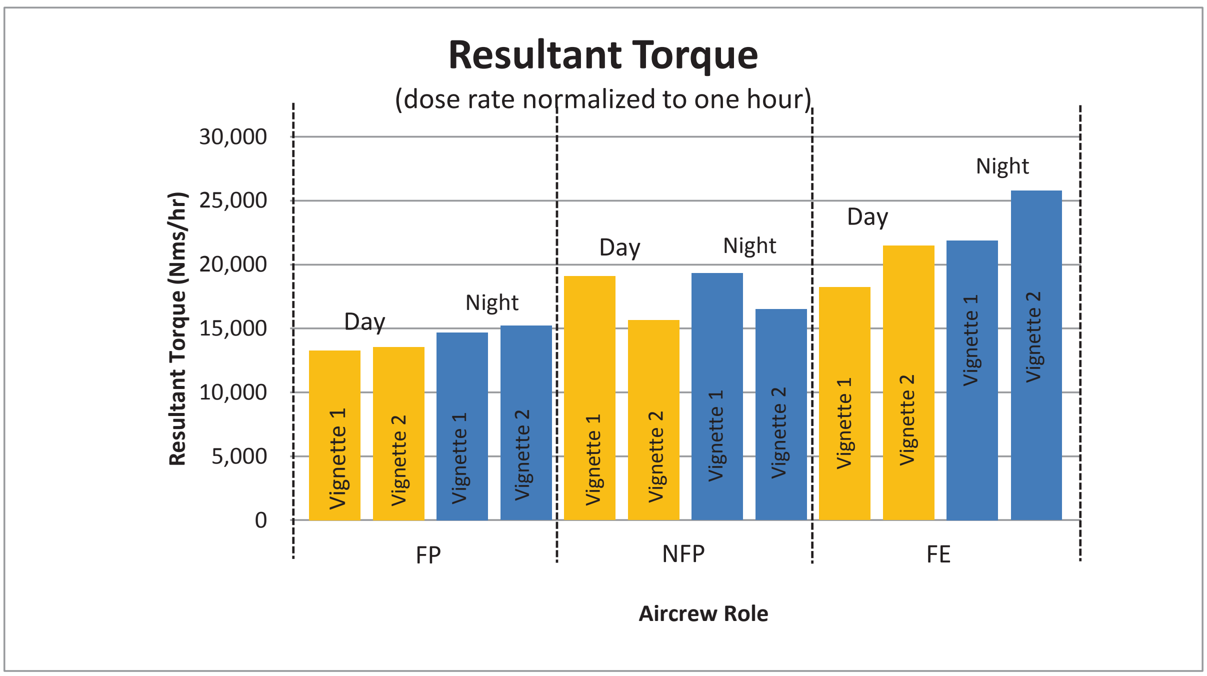

Figure 29: Neck Resultant Torque – Hourly Dose rate normalized between missions

5. Discussion

The primary aim of this project was to perform a Mission Function Task Analysis (MFTA) and Physical Demands Analysis (PDA) of the Griffon Helicopter aircrew (pilots and flight engineers) with a focus on mitigating aircrew neck strain/pain. This study began by investigating and updating a pre-existing 1997 Griffon MFTA and deconstructing the updated MFTA into a library of mission tasks comprised of associated postural sequences for each of the Flying Pilot, Non-flying Pilot, and Fight Engineer roles. This task library comprised the building blocks to enable the development of any number of possible customized Griffon mission types and characteristics. Based on the identified postural sequences from this library of mission tasks, six pilots and seven flight engineers underwent motion capture data collection by simulating the postural sequences for both day and night missions for each of the 12 Flying Pilot, 12 Non-flying Pilot, and 22 Flight Engineer postural sequences. These data were then analyzed for postural range of motion and forces on the neck to derive a Physical Demands Analysis for each of these postural sequences. The results of these analyses were then input into the mission-builder model to generate cumulative mission demands for neck strain in each aircrew role.

This section summarizes the findings of this study, introduces a new, integrated MFTA/PDA process model, describes ways and means to employ the model to evaluate possible neck strain solutions, proposes a number of administrative and engineering options to reduce neck strain, and, finally, proposes a number of areas for future work to expand and improve on the work to date.

5.1 Summary of Results

Results are summarized below for the postural and physical demands of all Griffon aircrew postural sequences and the cumulative demands for the two types of missions in both day and night.

5.1.1 Postural Sequences

The physical demands of the postural sequences for each aircrew role are summarized below for postural ranges of motion and forces.

5.1.1.1 Postures

5.1.1.1.1 Flight Engineer

Flexion and right axial rotation resulted in the largest average joint angles for the FE postural sequences. This was understandable because the scanning postural sequences require the FE to observe parts of the AC from the rear door position which can only be accomplished by leaning out of the door opening and adopting extreme postures.

The scanning postures also showed a trend in that the amount of time spent in a severe posture zone increased in the night condition. This was expected because NVGs have a narrow field of view which suggests that more neck rotation and flexion would be required to observe the necessary parts of the AC.

Using two of the injury criteria threshold values outlined in section 3.2.2.4.3 as a benchmark, postural sequences that are most likely to be a source of neck strain were identified. The following FE

postural sequences had an average flexion joint angle greater than 20°, and/or average right axial rotation angle greater than 45°:

- Scan Slung Load
- Scan Slope Landing
- Scan Confined
- Scan Regular Take-Off
- Scan Seated Door Closed
- Door Closing Seated
- Sling Hook Up Manual
- Scan Troops on Sill
- Scan Regular Landing
- Ingress.

The impact that trends in the FE postures, combined with the helmet force of gravity, have on the resultant torques and forces at the neck will be discussed in more detail in section 5.1.1.2.1.

5.1.1.1.2 Flying Pilot

Flexion and left/right axial rotation resulted in the largest average joint angles for FP postural sequences. This was expected because the outside scanning postures that require the FP to observe the peripheral of the AC while remaining in the seated position cause the FP to adopt severe neck postures.

The effect that NVGs had on the adopted postures was most predominantly observed in the outside scanning tasks, where average flexion and axial rotation generally increased, as well as the amount of time spent in moderate and severe posture zones.

Using two of the injury criteria threshold values outlined in section 3.2.2.4.3 as a benchmark, postural sequences that are most likely to be a source of neck strain were identified. The following FP postural sequences had an average flexion joint angle greater than 20°, and/or average right axial rotation angle greater than 45°:

- AC Egress
- AC Ingress
- Hard Turn FP Side
- Hard Turn NFP Side
- Inside Scan Dash Gauges
- Outside Scan Chin Bubble
- Outside Scan Confined
- Outside Scan Regular
- Outside Scan Wide
- Rapid Scanning

The impact that trends in the FP postures, combined with the helmet force of gravity, have on the resultant torques and forces at the neck will be discussed in more detail in section 5.1.1.2.2.

5.1.1.1.3 Non-Flying Pilot

Similar to FP posture results, flexion and right/left axial rotation resulted in the largest average joint angles for NFP postural sequences. With respect to axial rotation this was expected because NFPs are required to perform similar outside scans that require them to observe the periphery of the AC. However the source for the large flexion angles for the NFPs is caused by referencing equipment inside the AC, such as using the MX15, and CDU, and referencing maps. The high sources of neck flexion for NFPs in the day condition actually had a lower average neck flexion in the night condition because instead of looking through the NVG lenses the participants would look underneath the NVGs themselves. This was a strategy communicated during the MFTA interviews that is primarily used when observing equipment inside the AC.

Using two of the injury criteria threshold values outlined in section 3.2.2.4.3 as a benchmark, postural sequences that are most likely to be a source of neck strain were identified. The following NFP postural sequences had an average flexion joint angle greater than 20°, and/or average right axial rotation angle greater than 45°:

- AC Egress
- AC Ingress
- CDU AMS Use
- Hard Turn NFP Side
- Inside Scan Dash Gauges
- Map Doc Referencing
- MX15 Use
- Outside Scan Confined
- Outside Scan Regular
- Rapid Scanning

The impact that trends in the NFP postures, combined with the helmet force of gravity, have on the resultant torques and forces at the neck will be discussed in more detail in section 5.1.1.2.3.

5.1.1.2 Forces and Moments

AC Ingress and Egress resulted in some of the highest resultant torque and posterior shear averages for both day and night conditions for FP and NFPs. This is likely due to both the awkward postures that need to be adopted in order to fit through the pilot door and the awkward head movements that need to be adopted when buckling the restraint belt. During the MFTA interviews it was reported that, in most cases, the FP and NFP would don their helmet after they ingress the AC. Unfortunately, the data collection was limited due to the inertial sensor attached to the helmet and therefore it was required that for the FP and NFP ingress and egress, pilots were required to wear their helmet the entire time. Therefore, the joint angle results produced from the AC Ingress and Egress are a good representation of the posture that needs to be adopted however the force and moment results will be higher than if the pilot chose to not wear their helmet throughout the entire ingress and egress.

The resultant torque, compression and posterior shear loading parameters were selected to best characterize the physical demands of the FE, FP, and NFP postural sequences. The postural sequences that resulted in the highest average loading parameter depended on the root characteristic. For example, standing and sitting postures typically had higher compression and scanning postures typically had higher torque and posterior shear.

For almost all FE, FP, and NFP postural sequences the night condition resulted in higher average resultant torque, compression, and posterior shear. This is because adding the NVGs and counter weight increased the mass and moved the location of the center of mass. The loading parameter that was most significantly impacted by the night condition depended on the type of postural sequence.

Details specific to each air crew role are discussed in the following sections.

5.1.1.2.1 Flight Engineer

Resultant torque and posterior shear had the highest average values, and were most significantly increased at night, during postural sequences that required the FE to position themselves horizontally. This includes:

- Scan Slope Landing,
- Scan Troops on Sill,
- Equipment Handling Inside,

- Scan Slung Load, and
- Scan During Slide to Sling

These types of postures result in the largest resultant torque and posterior shear because they require a body posture that creates the largest moment arm perpendicular to the vertical force of gravity, and they align the vertical force of gravity with the posterior axis at the neck.

In contrast to torque and shear, upright seated postures resulted in higher compression forces because the upper body and head is aligned with the vertical force of gravity along the compression axis. Examples of FE postural sequences that had high compression forces are:

- Walking,
- Transit Seated,
- Door Opening Outside, and
- Door Closing Outside.

5.1.1.2.2 Flying Pilot

Due to the nature of the FP role the majority of loading is from compression force because, for nine of postural sequences, they are in a seated position. When the upper body is in an upright position the vertical force of gravity is aligned with the compression force. This is why very little variation was observed with compression force for the FP postural sequences.

Other than AC Ingress and Egress, resultant torque and posterior shear had the highest average values, and were most significantly increased at night, during FP postural sequences that required outside scanning in unique situations. This includes:

- Rapid Scanning,
- Outside Scan Wide,
- Outside Scan Chin Bubble, and
- Outside Scan Confined.

These types of postural sequences required the FP to not only adopt severe neck postures, but also move their upper body to gain the proper sight lines to scan the peripheral of the AC. Those two effects combined will simultaneously increase the perpendicular moment arm from the C7 to the helmet force of gravity and align the posterior/anterior axis with the vertical force of gravity, which will increase resultant torque and posterior shear.

5.1.1.2.3 Non-Flying Pilot

Compression results for NFPs were similar to FPs in that the nature of their role dictates most of their postures to be completed in a seated position. Therefore little variation was observed between NFP postural sequences with respect to compression force.

Other than AC Ingress and Egress, resultant torque typically had the highest average values for postural sequences that required the NFP to observe equipment inside the AC, such as:

- MX15 Use,
- CDU AMS Use, and
- Map Doc Referencing.

From the posture analysis, this result was expected because when the neck is flexed, the perpendicular moment arm from the C7 to the helmet force of gravity will increase and therefore resultant torque will increase.

Interestingly, although still a large contributor to high resultant neck torque at night, the postures that involved observing equipment inside the AC actually had lower torque values in the night condition. As previously discussed in section 5.1.1.1.3, this is because participants were looking underneath the NVGs and therefore not flexing their neck as much as in the day condition resulting in lower neck torque.

With respect to posterior shear NFP results were similar to FP results in that, other than AC ingress and egress, the NFP postural sequences that predominantly resulted in higher average posterior shear were ones that required outside scanning in unique situations. This included:

- Rapid Scanning,
- Outside Scan Confined, and
- Hard Turn NFP Side.

These types of postural sequences required the NFP to not only adopt severe neck postures, but also move their upper body to gain the proper sight lines to scan the peripheral of the AC. Those two effects combined will simultaneously increase the perpendicular moment arm from the C7 to the helmet force of gravity and align the posterior/anterior axis with the vertical force of gravity, which will increase resultant torque and posterior shear.

5.1.2 Individual Differences

Both pilots and FEs noted that there were individual differences in preferred body position and postural sequences when performing mission tasks. Reasons included anthropometric differences (largely stature), experience, pre-existing aches and pains over time, and individual technique differences.

It was recommended that we sample a range of individuals in each role to be able to reflect this variability in the analyses. A detailed investigation of trends amongst the individual differences is beyond the scope of the current project but is recommended for the future. It is possible that changes in technique alone may be able to reduce the neck loading.

5.1.3 Cumulative Demands

Very little research has been conducted on cumulative cervicothoracic loading and even less research has investigated relating this cumulative exposure to a mechanism of neck injury (Forde et al., 2011; Newell, 2003). This study was carried out to determine the Griffon Helicopter Aircrew's exposure to cumulative neck loading (dose rate) at the level of C7/T1.

When looking at the results for cumulative loading for both vignettes (Logistics Support and Surveillance Mission and Scan Load Training Mission), in general results show that night missions were more demanding than day missions, with the exception of some neck shear values for the FP.

For both the Logistics Support and Surveillance Mission and Slung Load Training Mission, the largest cumulative load for compression was experienced by the pilots for day and night. The largest cumulative load for left lateral shear was evidenced by the NFP during the Training Mission for day and night, and neck torque during the day mission. Conversely, the FE frequently experienced the largest cumulative load for tension, anterior shear, posterior shear, and right lateral shear for both day and night. The FE also experienced the highest cumulative load for left lateral shear and resultant torque except for those instances mentioned above. When looking at the normalized dose rate between the two missions, it can also be seen that for some measures of neck strain such as posterior shear, the FE experienced dose rates several times greater in magnitude than the FP (up to 917% greater). As well, FEs experienced noticeably higher posterior shear (140%) and resultant torque (120%) during the training mission example as compared to the operations mission example. This reinforces the perception by FEs that training missions may be more demanding on the neck than operational missions.

Furthermore, to identify the aircrew roles and tasks with the highest resultant torque values and to characterize the strain on the neck, a 7.8 Nm resultant torque threshold was set. This value was arbitrarily designated, based on a factor of two times the magnitude of the resultant torque for walking (day) for the FP, NFP, and FE. Results from this analysis showed that both the NFP and FE were required to sustain neck postures that exceed this threshold and were required to sustain these postures for prolonged periods. For the NFP it was consulting the MX-15, while for the FE it was a combination of several postural sequences which was exacerbated by the use of NVGs and the training mission. These findings were substantiated by the comments in SME interviews.

It should be stressed, however, that this 7.8 Nm threshold does not imply nor correspond to a physiological threshold, vigilance response threshold or any injury causing mechanism. It does suggest, however, the need for further research in these areas (i.e. MX-15 use, FE role in general, FE role in training missions, Instructor Flight Engineer) as well as the need to define a threshold for judging severity. With respect to defining a threshold, future research could investigate a vigilance response threshold for the Griffon Aircrew similar to the methodology that has been reported by Alem, Meyer, and Albano (1995), or a resultant torque threshold correlated to head posture measurements as discussed by Eklund, Odenrick, Zettergren, Johansson (1994).

5.2 The Integrated MFTA/PDA Model (IMPM)

To fulfill the aims of this project we had to develop new methodologies and processes using a number of different technologies, software tools, and integration methods. The resulting MFTA and PDA libraries, associated process steps, and links between tools has resulted in a new analytical process model for investigating and characterizing musculo-skeletal demands in Griffon helicopter aircrew: the Integrated MFTA/PDA Model (IMPM); see Figure 30 below.

The model includes a processing stream for each of the PDA and MFTA analysis methods. Both processing streams culminate in an integrated, cumulative MFTA / PDA demands analysis. Each of the process steps are independent analyses with outputs that can be used on their own and/or used as inputs to the next processing step.

The **PDA processing stream** can be used to analyze the demands of specific tasks, activities, and postural sequences associated with existing and new tasks, equipment, support devices, and cockpit/cabin design changes for both day and night missions across the range of aircrew differences in size, shape, and technique. Having identified the inputs to the PDA stream, the process begins with the Xsens motion capture of aircrew tasks and activities to derive real-time motion capture scripts, joint positions, angles, velocities, and accelerations. These outputs are input into the C-Motion Visual 3D biomechanical analysis tool to dynamically model these movements for any range of possible force inputs acting on the body (e.g. higher helmet weight or lower inertial forces) to derive the associated biomechanical demands (e.g. compression, shear, moments, resultant torque) on any joint in the body. These real-time results are input into a MATLAB processor to filter and parse the key movement sequences in the analysis. The results of all of these three process steps are then summarized and consolidated for each postural sequence into the PDA Library, including a paper summary of descriptive statistics, key graphs, task details, and images for both day and night missions. The library also includes live video recordings and Xsens motion capture (MOCAP) video files.

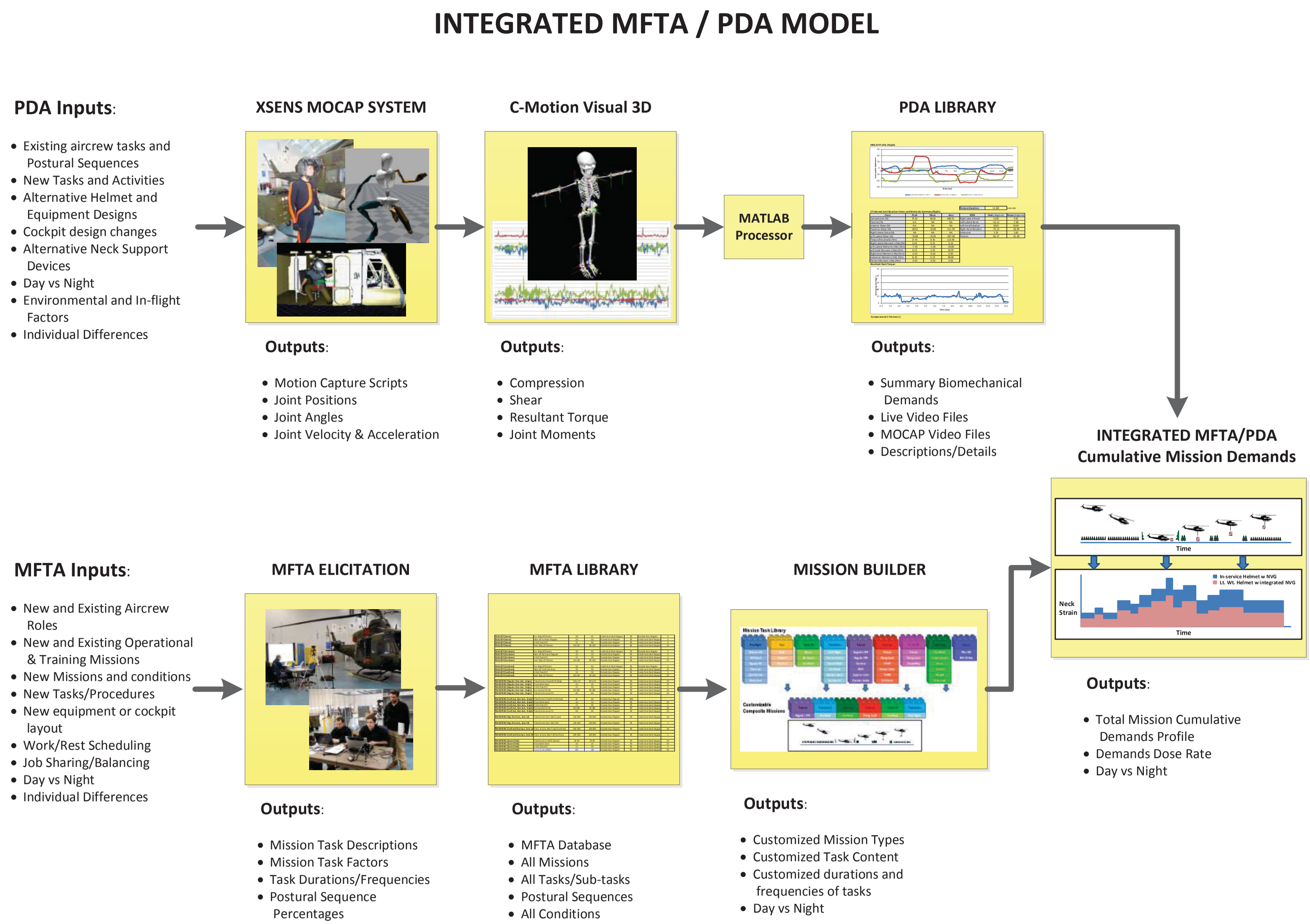

Figure 30: Integrated MFTA / PDA Model

The PDA Task Library provides the detailed physical demands of each and every postural sequence required to perform all of the task segments in the MFTA Task Library for each of the FP, NFP, and FE.

The **MFTA processing stream** can be used to capture existing and new missions, tasks, and procedures performed by any aircrew role in day or night, under any possible range of mission conditions. The MFTA process can also investigate alternative mission types, operational and training missions, alternative work/rest scheduling, job sharing, and new procedures resulting from new equipment and cockpit/cabin layouts. Having identified the inputs to the MFTA stream, the process begins with a knowledge elicitation process with aircrew to derive mission content, task descriptions, durations, frequencies, and the percentage of time spent performing postural sequences from the PDA library. Results of the MFTA elicitation are recorded in a MFTA database according to mission task blocks. These task blocks can then be combined in the Mission Builder to create customized missions, mission types, task content, customized task durations and frequencies, for day or night missions.

The results of the PDA stream can then be combined with the outputs of the MFTA Mission Builder to generate an analysis of cumulative mission demands over the course of an entire mission(s). These results can also be used to generate cumulative profiles for physical demands over weeks, months, years, and even a career.

Some examples for how this Integrated MFTA / PDA Model might be used are described below.

5.2.1 Helmet Design

Helmet weight and balance are known to be major factors in neck strain and discomfort. Absolute weight, center of mass, and inertial forces are all key parameters of helmet design. The IMPM can be used to simulate the effects of changes in any of these parameters for any number of possible helmet modifications or novel design alternatives. This rapid simulation capability provides an effective means of investigating the neck strain effects of any changes task-by-task, and mission-by-mission, for both acute and cumulative demands in each of the three aircrew roles. These processes enable a fast, objective, low-cost means of identifying the most likely beneficial designs to prototype and investigate further.

5.2.2 Cockpit/Cabin Design

The techniques and methodologies developed in this project enable a rapid mock-up of alternative cockpit/cabin design configuration and layout, and, wearing the Xsens suit, the postural sequence of work activities can be quickly captured for the new design mock-up. This information can then be entered into the PDA Library and run through the IMPM to compare the impact of possible cockpit/cabin design changes to the demands of the existing cockpit/cabin design.

5.2.3 Task Sharing

Job rotation and task sharing are common methods of reducing cumulative musculo-skeletal load on industrial works, by reducing the dose exposure of stresses on similar joints and muscles. Since the Griffon can be flown in both the right and left seats it may be possible to share certain tasks to enable pilots to rest certain muscles and reduce the dose exposure of specific postures. The IMPM can be used to identify high demand pilot tasks and then model opportunities for task sharing to reduce the overall aircrew's cumulative neck strain load.

5.2.4 Work/Rest Scheduling

Aircrew note that, while there are limits to total mission durations per day and the total number of consecutive days of flying before a day off, some missions are more demanding than others. The more demanding nature of night flying, for example, should necessitate more rest time than the equivalent for day flying. The same can be said for the differences between different types of missions. The IMPM can be used to help identify and resolve these differences between missions and provide insights into the prolonged effects of flying days versus rest days.

5.2.5 Other Body Areas

The Xsens motion capture files were used to provide the postural sequences for the physical demands analyses of neck strain for each of the 26 FE postural sequences and the 12 FP and NFP sequences for both day and night headwear conditions. While this project focused on the neck, the motion capture data were collected for 23 different body segments and 22 joints. As a result, other joints in the body (e.g. low back, shoulder) could be investigated in the same way to identify their physical demands in each mission task and aircrew role and the associated cumulative demands over time.

5.3 Options for Reducing Neck Strain

During the course of this project we have identified a number of opportunities to reduce neck strain among Griffon aircrew. These options are discussed below.

5.3.1 Lighter Helmet

Helmet weight is a major contributor to neck fatigue, discomfort, and injury. While reducing helmet weight might appear to be an obvious solution there are many complicating trade-offs required in optimizing any helmet design (e.g. weight , balance, inertial forces, protection, stand-off, comfort, communication integration, NVG integration, visor integration, etc.).

The IMPM provides an objective means of contributing to the trade-off analyses. Having an objective biomechanical guideline (i.e. 7.8 Nm resultant torque limit), it is possible to undertake a sensitivity analysis, using the IMPM, of all realistic weight/center of mass helmet combinations to identify which design combinations fall within biomechanical limits.

As an example, two postures were modeled: 'Transit Seated' to reflect an upright, level-head posture and 'Scan Slung Load' to reflect an FE task with high neck flexion. By reducing helmet weight from 3.36kg to 2.5kg we can see that helmet weight reduction benefits both types of postures in all three biomechanical measures (see Figure 31 below).

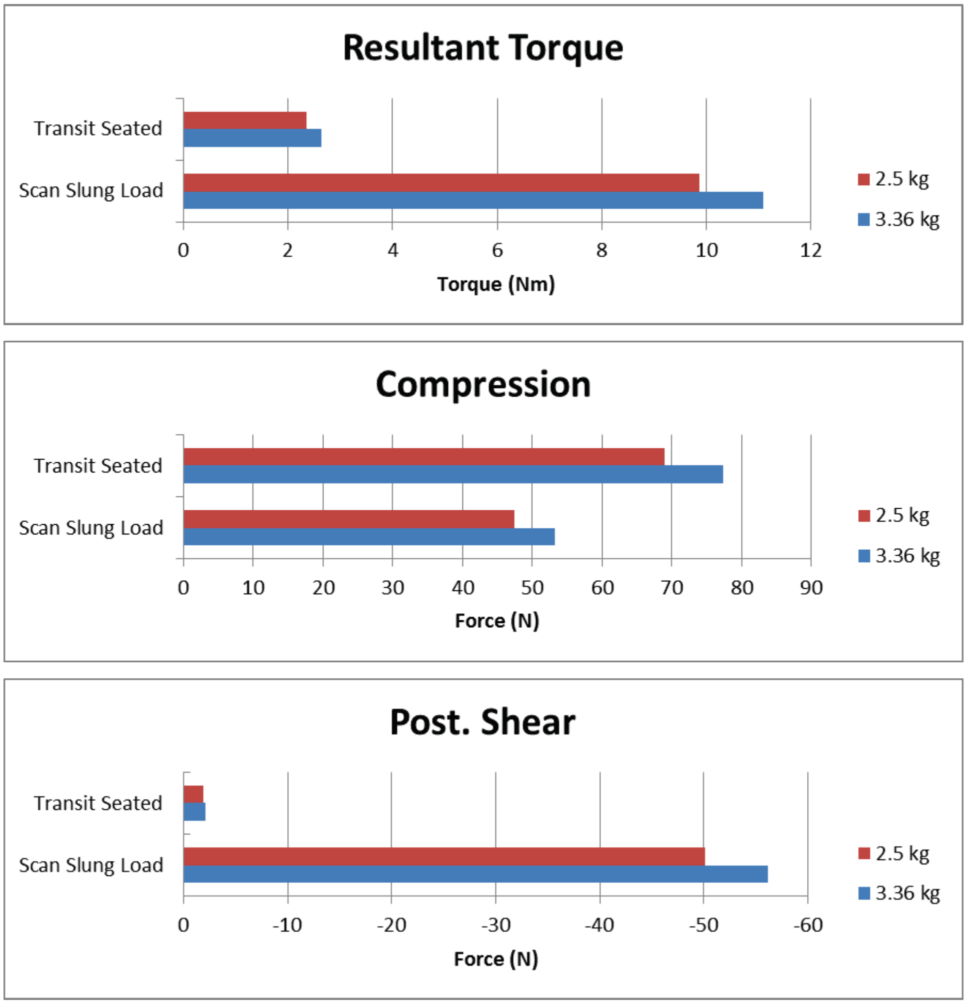

Figure 31: Effect of Helmet Weight Reduction

This IMPM approach can also be used to identify the incremental benefits of any change along a continuum of possible solutions for all possible postural sequences for all aircrew. For example, reducing helmet weight incrementally by 100 grams from worst to best case can be analyzed for biomechanical outcomes against measures of achievability (e.g. cost, complexity, integration) to derive the most promising and achievable design solutions.

5.3.2 Counter-Weight or Not

Some aircrew wear a counter-weight to offset the additional weight of the NVGs when worn on the helmet. The intent is to balance the center of mass of the helmet system over the cervical column to minimize the muscular demands of supporting the helmet. Therefore, improved balance is achieved at the expense of an increase in total helmet weight and inertia. For tasks requiring a fairly level head posture (e.g. sitting looking to the horizon) a counter-weight can effectively balance the helmet loads. However, for tasks requiring a lot of neck flexion (e.g. FE scanning) the added weight may only exacerbate neck loads.

As an example, the two postures from the previous example were modeled (i.e. 'Transit Seated' and 'Scan Slung Load' with and without a counter-weight (see Figure 32 below).

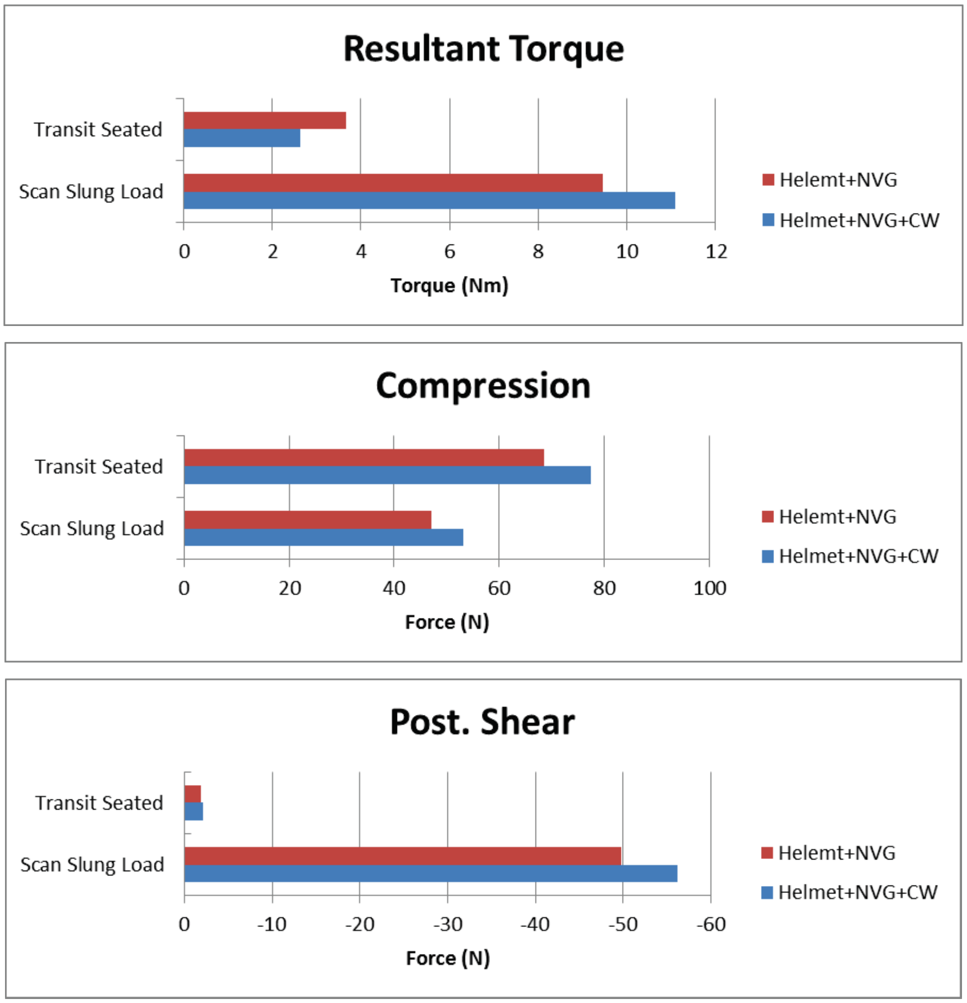

Figure 32: Counter-weight or Not

In the case of 'Transit Seated', the resultant torque is improved by the counter-weight as the NVG weight is balanced on the head, although this balancing is at the expense of higher compression due to the added weight. For the 'Scan Slung Load' however, the counter-weight results in a noticeably higher resultant torque, compression, and posterior shear, suggesting that a counter-weight only increases neck demands in this task. During our interviews, several FEs noted that the counter-weight seemed to increase neck loads for them due to the neck postures required in their job. The IMPM should be used to investigate the counter-weight issue more thoroughly to better understand the biomechanical implications for all tasks and all aircrew positions.

5.3.3 Quick-release NVG Mount

Demands on the neck increase significantly when wearing NVGs and the longer the NVGs are worn the faster the onset of muscular fatigue and the greater the likelihood of discomfort or even injury. It then makes sense to seek out opportunities to reduce the amount of NVG wear wherever possible. Examples include flying through dusk and dawn where NVGs are only required for a portion of the total flight time but they must be mounted and secured for the entire duration of the flight. As well, there are times when aircrew don't require the use of NVGs but removing them to gain some periods of rest are negated by the effort and time required to remove and re-attach them.

A one-handed, quick-connect/disconnect, hot-shoe connection to the ANVIS-9 night vision google would enable the aircrew to quickly remove and replace their NVG to limit the duration of NVG use to only those phases of the mission requiring night vision and to enable them to exploit opportunities to rest their neck musculature when mission conditions allow and rapid dark adaptation is not essential (e.g. an administrative hold on the ground).

Quick-disconnect, hot-shoe connectors are readily available for the ANVIS-9. The bigger issue is an easily accessible stowage solution on the torso with a lanyard securement.

5.3.4 Neck Support (chin rest concept)

In a static neck posture under load, the muscles fatigue and get weaker over time without rest. These weaker muscles are more susceptible to acute injury. One way to reduce the muscular demand on the neck is to support the loads on the head in a different way and provide the neck muscles an opportunity to rest. The highest force moments for pilots were observed in the extension moments, suggesting that a means of supporting the head in forward flexion might be beneficial.

During an interview with a long-serving pilot, he mentioned that he had been given a tip from an instructor, back in his Kiowa days, to reduce neck strain and rest the neck muscles. The tip suggests making a fist, placing it on their chest below their chin, and then resting their chin, and associated headwear weight, on the fist as a chin rest. He swore that it was effective and had even passed the tip on to other pilots who also used this method to rest their neck over the years. The obvious downside of such a technique is the loss of one hand as the support.

A similar type of hands-free chin support could be an effective, inexpensive option for resting prolonged static neck extension postures. We would envision a small cube-shaped pad, comprised of a firm vibration-damping material, which offered three pad thicknesses depending on how the cube was rotated. For example, the thickest side of the cube would be used for long flights in a normal flying posture, the middle thickness for prolonged MX-15 use, and the thinnest side for prolonged CDU use.

5.3.5 RADALT Remote Display

Flight Engineers must consult the radio altimeter (RADALT) frequently during landing, 2-full checks, slinging, etc., to determine the distance of the aircraft to the ground, usually while simultaneously scanning outside the aircraft with the cabin door open. To consult the RADALT gauge, while in the cabin door position, the FE must lean back into the cabin, rotate and crane their neck around to observe the gauge on the dashboard in front of the Non-Flying Pilot. This movement and posture is demanding on the structures of the neck, is not ideal for ready a detailed gauge at such a viewing distance, and removes the FE's attention from their important scanning tasks outside the aircraft.

One possible solution is to remote a RADALT display to a location proximal to the cabin door so the FE can easily consult the display without excessive neck movements and without disconnecting their attention from their outside scanning tasks.

5.3.6 Sling Length

FEs adopt a wide range of extreme postures during the slide up to a load for slinging (e.g. standing and extending out, kneeling and hanging out, or lying prone and looking under) so that they can observe the proximity of the aircraft to the load and guide the pilot in as close as possible (i.e. about 0.5m from the nose of the Griffon). One of the reasons the aircraft must be guided in so close to the load to be slung is the short length of the sling itself (20 feet long). FEs have noted that a longer sling (e.g. 30-40 feet long) would greatly reduce the need for the extreme viewing postures currently required. There are currently two common sling lengths available in the Griffon inventory (i.e. 20 and 40 ft.) but only the 20 ft length was used.

5.3.7 Remote Viewing below the Aircraft

Several FE tasks require extreme, demanding neck postures to observe the ground, obstacles, and aircraft clearance under the Griffon during landings and slung loads. To be able to observe ground obstacles and structures under the aircraft (e.g. far slid, wire cutter) the FE must lie prone on the cabin deck, extend out from the side of the cabin door, and hang their head and upper torso under the aircraft, while rotating, flexing, and extending their neck to perform and effective scan. These demands can be made even worse by the forces of rotor down-draft, inclement weather, and snow/dust balls.

These problematic postures and situations could be avoided by using cameras mounted under the aircraft to provide remote viewing of the underside of the aircraft. A single, fixed, wide field of view camera with low light and night vision capability, and sufficient resolution, would be sufficient and could be remoted to a display in the cabin for FE viewing.

5.3.8 Dual-Seat MX-15 Usability

In vignette 1, the high neck strain demands of viewing and operating the MX-15 were disproportionately high for the NFP for extended durations, as compared to the FP. While many tasks can be shared between the left and right seats in the Griffon, the MX-15 is specifically designed for left seat use. Therefore, this prolonged burden must be borne for the entire duration by only one pilot. If the MX-15 mount were to be reconfigured to enable operation from both the left and right seats then the demands could be balanced between the two pilots in a meaningful work/rest schedule. Balancing the MX-15 workload between two pilots would not only significantly reduce neck strain demands but vigilance would likely be improved and overall mental demands reduced over the course of a given mission.

5.4 Future Work

Suggestions for future work are described below.

5.4.1 Collect Combat and SAR Data

The data collected from 400 Sqn did not include postural sequences associated with combat operations (e.g. door gunnery, rappelling) nor SAR operations (e.g. stokes litter, Billy Pugh, marine rescue, search). MFTA data was collected for both types of missions but we were only able to access one pilot for each of combat and SAR operations. As well, some tasks could only be simulated at 400 Sqn; for example, the squadron's MX-15s were on loan to another unit so we could only simulate its use with one pilot with extensive MX-15 experience.

To ensure that the MFTA and PDA Libraries are complete, comprehensive, and validated, we recommend extending the MFTA and PDA data collection to a Tactical Helicopter Squadron, with combat experience, and a Rescue Squadron for SAR tasks.

5.4.2 Investigate Other Missions

A single composite logistical support and surveillance mission and a single representative training mission were developed for the purposes of this report to explore the issue of cumulative demands over the course of a typical mission during both day and night conditions.

Using the MFTA Library, the PDA Library, and the IMPM, it is possible to construct any number of missions which reflect different content, goals, objectives, and situations. By generating and analyzing different types of missions it is possible to compare and contrast the demands of each mission type and relate these demands to issues of dose exposure, job rotation, and work/rest scheduling.

5.4.3 FE Training Flights

During their interviews, several FEs noted that we should not focus solely on operational missions and that we should also investigate FE training and the demands on FE instructors. During the Basic Flight Engineer Course (BFEC) students are required to repeat FE tasks until they achieve sufficient proficiency. This typically requires flying missions where the FE is required to repeat the same task over and over again, thereby minimizing the resting benefits of the lower-demand transit tasks and maximizing the more demanding task evolutions requiring more extreme postures. The training mission (slung load) analyzed in this report demonstrates the repetitive, high-load, nature of training for the FE student.

Ideally, the in-flight training curriculum would be modeled in the IMPM, for each task training flight, to determine which training events are most musculo-skeletally demanding on FEs so that the number of training evolutions and/or the total session duration might be modified, or strategic rest breaks provided, to reduce the magnitude of exposure.

Of greater concern are the demands on the FE instructors during these training flights. To effectively instruct the student, the FE instructor will demonstrate the task and then observe the student in the performance of the task. To effectively observe the student, the FE instructor must adopt postures that are even more extreme to be able to observe the student, and see what the student is seeing, without obstructing them in their task. As an example, scanning during landing with troops on the sill places the FE in an awkward, stooped posture to enable them to still perform their scanning task while looking over and around the troops sitting on the sill of the cabin door. The musculo-skeletal demands of this task evidenced some of the highest levels of resultant torque and posterior shear,

suggesting that the need to adopt viewing postures while working around another person may noticeably increase the associated demands of the task on the neck.

Given that these older, more experienced, instructor FEs must also perform these demanding observation postures repeatedly over a 2-3 hour BFEC training mission, and may perform more than one such mission per day, we believe that this role warrants special investigation to better understand the magnitude of the demands on the FE instructors and the best possible ways and means to mitigate or reduce these demands.

5.4.4 Additional In-Flight Demands

The PDA data collected for the PDA Library is based on postural simulations in a grounded Griffon. The results of this approach are likely conservative and do not reflect the other forces and postural factors that occur in real flight that contribute to demands on the neck. Forces due to acceleration (g-forces) during aircraft maneuvers act to increase forces on all members of the crew. The attitude of the aircraft during flight may also affect the forces experienced at the neck. Wind blast and rotor down-draft both apply forces on the FE when working near or outside the cabin door.

These effects are measureable and could be included in the PDA models to reflect the forces acting on the aircrew more accurately.

5.4.5 Individual Differences

Individual differences can significantly affect the demands of any task. Aircrew size and shape will affect viewing angles and sight lines, thereby altering neck postures. Individual technique can vary quite considerably due to aircrew anthropometry, performance optimizing strategies, neck strain reducing strategies, strength and range of motion, and pre-existing discomfort or injury. The effects of these differences should be investigated to determine if certain aspects place aircrew at greater risk and to determine if there are better techniques for reducing neck strain.

5.4.6 Cumulative Fatigue Effects

The IMPM currently treats each postural sequence as unique and independent, and the relative strain of any subsequent task is unaffected by any fatigue affects from preceding tasks. However, during prolonged muscular exertion muscles will fatigue and become less capable of supporting loads and sudden increases in force. Cumulative fatigue effects should be investigated to determine if this factor can be incorporated into the IMPM to better reflect the higher fatigue, discomfort, and injury risk associated with prolonged task exposure during extended missions.

5.4.7 Other Airframes

The IMPM model has been developed for the Griffon aircraft but the same processes could be applied to the Chinook or other airframe to investigate, quantify, and compare musculo-skeletal demands.

5.4.8 Integrating Digital Human Modeling (DHM)

Opportunities exist for integrating digital human modeling software (e.g. Siemens JACK) into the IMPM process to further support and enhance analysis and design interventions. Efforts were made in this project to integrate the motion capture data with digital human modeling software and relate these to a 3D surface-scan model of the Griffon. While the motion capture files were transferable as motion scripts into the DHM software the resulting motions were not sufficiently precise for the purposes of this study. However, further work with the DHM manufacturer would likely be able to resolve these issues.

6. References

Adam, J. (2004). *Results of NVG-induced neck strain questionnaire study in CH-146 Griffon aircrew.* Defence R&D Canada (DRDC) – Toronto. DRDC Toronto TR 2004-153.

Alem, N.M., Meyer, M.D., and Albano, J.P. (1995). *Effects of head supported devices on pilot performance during simulated helicopter rides.* USAARL Report No. 95-37.

Anderson, J.H., Kaergaard, A., Mikkelsen, S., Jensen, U.F., Frost, P., Bonde, J.P., Fallentin, N., & Thomsen, J.F. (2003). Risk Factors in the onset of neck/shoulder pain in a prospective study of workers in industrial and service companies. *Occup Environ Med, 60*, 649-654. doi: 10.1136/oem.60.9.649

Ariens, G. A. M., van Mechelen, W., Bongers, P. M., Bouter, L. M., van der Wal, G. (2000). Physical risk factors for neck pain. *Scandinavian Journal of Work, Environment and Health. 26*(1), 7 – 19.

Ashrafiuon, H., Alem, N. M. and McEntire, B. J. (1998). *Effects of weight and center of gravity location of head-supported devices on neck loading (Reprint)*. U.S. Army Aeromedical Research Laboratory.

B-GA-002-146/FP-001. CH-146 Griffon Standard Manoeuvre Manual. 1 Canadian Air Division Manual. Change 1: 2012-12-15

Buhrman, J. R. and Perry, C. E. (1994). Human and manikin head/neck response to +Gz acceleration when encumbered by helmets of various weights. *Aviat Space Environ Med, 65*(12), 1086-90.

CMC Electronics (1997) Griffon Mission Function Task Analysis. Defence R&D Canada (DRDC) – Toronto. DRDC Toronto.

Eklund, J., Odenrick, P., Zettergren, S., Johansson, H. (1994). Head posture measurements among work vehicle drivers and implications for work and workplace design. *Ergonomics; 37*(4), 623-639.

Eveland, E. S. (2002). *Neck muscle response to changes in helmet loading under +Gz acceleration - gender differences (PhD dissertation)*, WRIGHT STATE UNIVERSITY. PhD: 158.

Forde, K. A., Albert, W. J., Harrison, M. F., Neary, J. P., Croll, J., Callaghan, J. P. (2011). Neck loads and posture exposure of helicopter pilots during simulated day and night flights. *International Journal of Industrial Ergonomics, 41*, 128 – 135.

Freivalds, A. and McCauley, D. S. (1990). Biodynamic simulations of helmet mass and center-of-gravity effects. *Journal of Safety Research, 21*(4), 141-148.

Gordon, C.C., Blackwell, C.L., Bradtmiller, B., Parham, J.L., Hotzman, J., Paquette, S.P., Corner, B.D., & Hodge, B.M. (2013) *2010 Anthropometric Survey of U.S. Marine Corps Personnel: Methods and Summary Statistics.* NATICK/TR-13/018, Natick, MA: U.S. Army Natick Soldier Research, Development and Engineering Center.

Henry Dreyfuss Associates. (2002). The Measure of Man & Women (rev ed.). New York, NY: John Wiley & Sons.

Kumar, S. (2001). Theories of musculoskeletal injury causation. *Ergonomics, 44*(1), 17 – 47.

Lee, C. M., Freivalds, A. and Lee, S. Y. (1991). Biodynamic simulations of the effect of a neck-mounted air bag on the head/neck response during high G acceleration. *Aviat Space Environ Med, 62*(8), 747-53.

McEntire, B. J., Alem, N. and Brozoski, F. T. (2004). Parachutist neck injury risk associated with head-borne mass. *U.S. Army Medical Department JOURNAL*, 30-35.

McEntire, B. J., Shanahan, D. F. (1998). *Mass Requirements for Helicopter Aircrew Helmets (Reprint)*. U.S. Army Aeromedical Research Laboratory. Fort Rucker, Alabama.

McLaughlin, T. (2013). *Neck Strain in Air Crew Literature Search*. National Research Council Canada Institute for Scientific and Technical Information. STI Search 15458.

Mertz, H. J. and Patrick, L. M. (1971). Strength and response of the human neck. *15th Stapp Car Crash Conference* (pp. 2903-2928).

Mobasher, A. A., Brozoski, F. T., McEntire, B. J. and Alem, N. M. (1998). *Effects of seat stroke distance on the allowable mass of head supported devices (Reprint)*. Alabama, U.S. Army Aeromedical Research Laboratory. Fort Rucker.

Muzzy, W. H., Bittner, A. C. and Willems, G. C. (1986). Safety evaluation of helmet and other mass additions to the head. *A Cradle for Human Factors. Proceedings of the Human Factors Society 30th Annual Meeting.* Dayton, Ohio, USA, The Human Factors Society. 2 (pp. 1301 – 1305).

MVN BIOMECH. (n.d.). Retrieved May 22, 2014, from http://www.xsens.com/products/mvn-biomech/

NAKAZA, E.T. (2007). *Assessment of injury risks associated with wearing the enhanced combat helmet and night vision goggle - driver: frontal vehicle collision study*. M.Sc. Thesis, University of New South Wales, Australia.

Neary, J. P., Salmon, D. M., Harrison, M. F., Albert, W. J. (2010). *Final Report: Night Vision Goggles-Induced Neck Strain and Muscle Fatigue Characteristics of Griffon Helicopter Personnel*. Canadian Forces Quality of Life Grant #1725981 and Military Health Program W3931-050513-001/SV.

Perry, C. E., Buhrman, J. R. and Knox, F. S. (1993). Biodynamic testing of helmet mounted systems. *Designing for Diversity. Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting*. Seattle, Washington, The Human Factors and Ergonomics Society. 1 (pp. 79 – 83).

Shender, B. S., Paskoff, G., Askew, G., Coughlan, R. and Isdahl, W. (2001). *Determination of head and neck loads and moments during tactical and rotary wing maneuvering acceleration*. Patuxent River, Maryland, Department of the Navy, Naval Air Warfare Center Aircraft Division.

Tack, D. W., Nakaza, E. T. (2013). *Mission, Function, Task Analysis / Physical Demands Analysis Plan for Griffon Helicopter Crew Neck Strain Project*. Defence Research and Development Canada – Toronto Research Centre. DRDC Toronto CR-2013-139.

List of Acronyms/Abbreviations

CAD	Canadian Air Division
CoM	Centre of Mass
DAR	Director of Air Requirements
DTAES	Director Technical Airworthiness and Engineering Support
FE	Flight Engineer
FP	Flying Pilot
IMPM	Integrated MFTA PDA Model
MFTA	Mission Function Task Analysis
NFP	Non-Flying Pilot
PDA	Physical Demands Analysis
SME	Subject Matter Expert

Annex A: MFTA Library

Flying Pilot (FP) and Non-Flying Pilot (NFP for posture 1):

Block	Task	Comments	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %	NFP Post 1	NFP Post 1 %
PRE-FLIGHT	Load Mission Kit	from the hangar (if helmet)	600	900	Walking	100			Walking	100
PRE-FLIGHT	Mission Kit Check (Hook)		120	120	Inside Scan Dash Gauges	100			Inside Scan Dash Gauge	100
PRE-FLIGHT	Open and Ingress AC		300	480	AC Ingress	100			AC Ingress	100
PRE-FLIGHT	Start-up/Last Chance Insp.		600-900	600-900	Outside Scan Regular	25	Inside Scan Dash Gauges	75	Outside Scan Regular	20
PRE-FLIGHT	Post-start Checks		60	69	Outside Scan Regular	50	Inside Scan Dash Gauges	50	Outside Scan Regular	20
PRE-FLIGHT	Pre-departure Checks		60	60	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TAXI (Field)	Pre-taxi Checks	night adds wiggle checks	25	45	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Inside Scan Dash Gauge	50
TAXI (Field)	Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TAXI (Field)	Taxi Field	reposition AC	60	60	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Regular	50
TAXI (Airport)	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
TAXI (Airport)	Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TAXI (Airport)	Post-Take off Checks		60-120	60-120	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Regular	50
TAXI (Airport)	Pre-taxi Checks	night adds wiggle checks	25	45	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Inside Scan Dash Gauge	50
TAXI (Airport)	Taxi to Hold Area		60	60	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Regular	50
TAXI (Airport)	Land at Hold Area		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TAXI (Airport)	Obtain IFR Clearance	then add take-off	60	60	Outside Scan Regular	50	Inside Scan Dash Gauges	50	CDU/AMS Use	100
TAKE-OFF (Hover)	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
TAKE-OFF (Hover)	Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TAKE-OFF (Hover)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TAKE-OFF (Hover)	Post-Take off Checks		60-120	60-120	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Confined	50
TAKE-OFF (No Hover)	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
TAKE-OFF (No Hover)	Take-off No Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	70
TAKE-OFF (No Hover)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TAKE-OFF (No Hover)	Post-Take off Checks		60-120	60-120	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Confined	50
TAKE-OFF (Confined)	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
TAKE-OFF (Confined)	Take-off Confined Area		30	30	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Confined	75
TAKE-OFF (Confined)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TAKE-OFF (Confined)	Post-Take off Checks		60-120	60-120	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Confined	50
TRANSITION (Regular, Non-tact., Single)	Transition to Forward Flt (Reg)	Single AC, Regular	10 to 15	10 to 15	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
TRANSITION (Regular, Non-tact., Single)	Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Regular, Non-tact., Single)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TRANSITION (Regular, Non-tact., Single)	Non-tactical Climb	duration depends on alt.	60-360	60-360	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
TRANSITION (Regular, Non-tact., Single)	Transition to Level Flt		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Confined, Non-tact., Single)	Transition to Fwd Flt (Confined)	Single AC, Confined	30	30	Outside Scan Regular	100			Outside Scan Regular	50
TRANSITION (Confined, Non-tact., Single)	Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Confined, Non-tact., Single)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TRANSITION (Confined, Non-tact., Single)	Non-tactical Climb	duration depends on alt.	60-360	60-360	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
TRANSITION (Confined, Non-tact., Single)	Transition to Level Flt		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Reg. Non-tact., Sect. Ld)	Transition to Sect. Mov't Lead		120-240	120-240	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Reg. Non-tact., Sect. #2)	Transition to Sect. Mov't #2		120-240	120-240	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	70
TRANSITION (Confined Non-tact., Sect. Ld)	Trans. to Sect. Mov't Lead Confined		240-300	240-300	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Confined Non-tact., Sect. #2)	Trans. to Sect. Mov't #2 Confined		240-300	240-300	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	70

Block	Task	Comments	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %	NFP Post 1	NFP Post 1 %
TRANSITION (Zoom Climb)	Transition to Fwd Flt (Zoom)		30-40	30-40	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
TRANSITION (Zoom Climb)	Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Zoom Climb)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TRANSITION (Zoom Climb)	Zoom Climb (6000')	up to 6000'	180	180	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
TRANSITION (Other Climbs)	Transition to Forward Flt (Reg)	Single AC, Regular	10 to 15	10 to 15	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
TRANSITION (Other Climbs)	Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Other Climbs)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
TRANSITION (Other Climbs)	"insert other climb type below"									
TRANSITION (Other Climbs)	Transition to Level Flt		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
TRANSITION (Climb to Contour Flt)	Non-tactical Climb to Contour (<100')		60	60	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
TRANSITION (Flat Ascent Climb)	Flat Ascent Climb (100-200')	100-200'	60	60	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
TRANSITION (Spiral Climb)	Spiral Climb (3000')	3000'	120	120	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
NAVIGATION	Route Planning		600	600	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	20
NAVIGATION	Enroute Navigation	Ongoing during transit	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
RE-BROADCASTING	Set up Comms for Re-bro	Re-broadcasting in Loiter	120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	10
RE-BROADCASTING	Conduct Re-bro in Loiter		3600-4800	3600-4800	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	10
TRANSIT TYPE (Regular VFR)	Transit Regular VFR	Visual flight rules			Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
TRANSIT TYPE (Regular IFR)	Transit Regular IFR	Instrumented flight rules			Inside Scan Dash Gauges	80	Inside Scan Ceiling Switc	20	Outside Scan Regular	80
TRANSIT TYPE (Contour)	Transit Contour	example 30 min	1800	1800	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	60
TRANSIT TYPE (NOE)	Transit NOE	short transit movements	30-60	30-60	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	40
LANDING APPROACH (Straight Term. Nav.)	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	40
LANDING APPROACH (Straight Term. Nav.)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
LANDING APPROACH (Straight Term. Nav.)	Conduct Term. Nav. Straight	incl straight descent	120-180	120-180	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
LANDING APPROACH (Straight Term. Nav.)	Final Approach		15-45	15-45	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
LANDING APPROACH (Straight Term. Nav.)	Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
LANDING APPROACH (Straight Term. Nav.)	"insert a landing type below"									
LANDING APPROACH (Spiral Term. Nav.)	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	40
LANDING APPROACH (Spiral Term. Nav.)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
LANDING APPROACH (Spiral Term. Nav.)	Conduct Term. Nav. Spiral	incl Spiral Descent	180	180	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
LANDING APPROACH (Spiral Term. Nav.)	Final Approach		15-45	15-45	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
LANDING APPROACH (Spiral Term. Nav.)	Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
LANDING APPROACH (Spiral Term. Nav.)	"insert a landing type below"									
LANDING TYPE (Hover Regular)	Landing Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
LANDING TYPE (Tactical Regular)	Landing Tactical Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	70
LANDING TYPE (Hover Confined)	Landing Hover Confined		180-300	180-300	Outside Scan Confined	95	Inside Scan Dash Gauges	5	Outside Scan Confined	80
LANDING TYPE (Hover Sloped)	Landing Sloped		30-60	30-60	Outside Scan Confined	80	Inside Scan Dash Gauges	20	Outside Scan Confined	70
LANDING TYPE (Hover Obscurred)	Landing Visually Obscurred		10	10	Outside Scan Chin Bubble	95	Inside Scan Dash Gauges	5	Outside Scan Confined	70
PICK-UP (Troops)	Troops		300	600	Outside Scan Regular	75	Inside Scan Dash Gauges	25	Outside Scan Regular	50
PICK-UP (Troops)	Secure Troops/Equip in AC		60	60	Outside Scan Regular	50	Inside Scan Dash Gauges	50	Outside Scan Regular	50
PICK-UP (Slung Load, Manual)	Landing Slide to Sling		15-20	15-20	Outside Scan Regular	100			Outside Scan Regular	90
PICK-UP (Slung Load, Manual)	Hook up Slung Loads FE Manual		300	450	Outside Scan Regular	100			Outside Scan Regular	90
PICK-UP (Slung Load, Manual)	Take-off with Slung Load		60	60	Outside Scan Regular	100			Outside Scan Regular	50

Block	Task	Comments	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %	NFP Post 1	NFP Post 1 %
PICK-UP (Slung Load, Manual)	Climb with Slung Load		60	60	Outside Scan Confined	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
PICK-UP (Slung Load, Manual)	2-Full Check NFP Pilot		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Inside Scan Dash Gauge	50
PICK-UP (Slung Load, Manual)	Transition to Fwd Flt (Slung Reg)		20	40	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
PICK-UP (Slung Load, Manual)	Control AC with Slung Load		15	15	Outside Scan Regular	100			Outside Scan Regular	10
PICK-UP (Slung Load, Manual)	Transit with Slung Load	duration mission depend.			Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
PICK-UP (Slung Load, Manual,Confined)	Landing Slide to Sling		15-20	15-20	Outside Scan Regular	100			Outside Scan Regular	90
PICK-UP (Slung Load, Manual,Confined)	Hook up Slung Loads FE Manual		300	450	Outside Scan Regular	100			Outside Scan Regular	90
PICK-UP (Slung Load, Manual,Confined)	Take-off with Slung Load		60	60	Outside Scan Regular	100			Outside Scan Regular	50
PICK-UP (Slung Load, Manual,Confined)	2-Full Check NFP Pilot		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Inside Scan Dash Gauge	50
PICK-UP (Slung Load, Manual,Confined)	Climb with Slung Load		60	60	Outside Scan Confined	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
PICK-UP (Slung Load, Manual,Confined)	Transition to Fwd Flt (Slung Confined)		45	90	Outside Scan Regular	100			Outside Scan Regular	50
PICK-UP (Slung Load, Manual,Confined)	Control AC with Slung Load		15	15	Outside Scan Regular	100			Outside Scan Regular	10
PICK-UP (Slung Load, Manual,Confined)	Transit with Slung Load	duration mission depend.			Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
PICK-UP (Slung Load, TAMS)	Transition to Hover		30-60	30-60	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
PICK-UP (Slung Load, TAMS)	Slung Loads TAMS	Using pennant at 10' hover	120	120	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	90
PICK-UP (Slung Load, TAMS)	Take-off with Slung Load		60	60	Outside Scan Regular	100			Outside Scan Regular	50
PICK-UP (Slung Load, TAMS)	Climb with Slung Load		60	60	Outside Scan Confined	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
PICK-UP (Slung Load, TAMS)	Transition to Fwd Flt (Slung Reg)		20	40	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
PICK-UP (Slung Load, TAMS)	Control AC with Slung Load		15	15	Outside Scan Regular	100			Outside Scan Regular	10
PICK-UP (Slung Load, TAMS)	Transit with Slung Load	duration mission depend.			Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
PICK-UP (FARP)	FARP Pick-ups	fuel and ammo	600-900	600-900	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	95
PICK-UP (SAR Hoist Stokes Litter)	SAR Hoist Stokes Litter									
PICK-UP (SAR Hoist SAR Tech)	SAR Hoist SAR Tech									
DROP-OFF (Troops)	Landing Tactical Regular	with troops on the sill	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	70
DROP-OFF (Troops)	Troops		60-240	60-240	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Regular	50
DROP-OFF (Slung Load, Pilot Drop)	Transition to Hover		30-60	30-60	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
DROP-OFF (Slung Load, Pilot Drop)	Slung Loads Drop (Pilot)		30-60	45-90	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	90
DROP-OFF (Slung Load, Manual)	Slung Load Landing		90-600	135-900	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	90
DROP-OFF (Slung Load, Manual)	Slung Load Unhook Manual		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
DROP-OFF (SAR Hoist SAR Tech)	SAR Hoist SAR Tech									
DROP-OFF (SAR Hoist Stokes Litter)	SAR Hoist Stokes Litter									
DROP-OFF (SAR Hoist Billy Pugh)	SAR Hoist Billy Pugh									
DROP-OFF (Troops, Rappelling)	Rappelling Troops									
CHECKS (2-Full FE)	2-Full Check FE		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
CHECKS (2-Full NFP)	2-Full Check NFP Pilot		15	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Inside Scan Dash Gauge	50
CHECKS (SAR)	SAR Check									
RECCE (MX-15)	Plan ISR		180-300	180-300	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	60
RECCE (MX-15)	Conduct ISR Profile	2hr flights	7200	7200	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	15
OBS MANEUVER (Pop up)	Plan Observation Maneuver		60	60	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	20

Block	Task	Comments	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %	NFP Post 1	NFP Post 1 %
OBS MANEUVER (Pop up)	Execute Obs Maneuver	pop up to 100' from cover	5 to 7	5 to 7	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	100
OBS MANEUVER (Pop up)	Assess/Record/Communicate	behind cover	300	300	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	10
OBS MANEUVER (Pop up)	Reposition AC		300-600	300-600	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	90
COMBAT ATTK (Door Guns)	ISR In-bound to TIC	door is pinned open	180	180	Outside Scan Regular	90	Inside Scan Dash Gauges	10	MX-15 Use	90
COMBAT ATTK (Door Guns)	ISR Observation	pop up flight	60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
COMBAT ATTK (Door Guns)	Scan and ID Targets		180	180	Outside Scan Regular	100			Outside Scan Regular	34
COMBAT ATTK (Door Guns)	Gunnery Attack Run	assume 4 passes	240	240	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
COMBAT ATTK (Door Guns)	Run out and Turn for each Approach	dogbone profile	240	240	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
REACT TO MISSILE (FP side)	Detect Threat		1 to 3	1 to 3	Inside Scan Dash Gauges	100			Inside Scan Dash Gauge	100
REACT TO MISSILE (FP side)	Assess Threat (FP side)	assumes FP side	3 to 5	3 to 5	Hard Turn FP Side	100			Inside Scan Dash Gauge	50
REACT TO MISSILE (FP side)	Movement to Cover		120	120	Outside Scan Regular	70	Inside Scan Dash Gauges	30	Map/Doc Referencing	90
REACT TO MISSILE (NFP side)	Detect Threat		1 to 3	1 to 3	Inside Scan Dash Gauges	100			Inside Scan Dash Gauge	100
REACT TO MISSILE (NFP side)	Assess Threat (NFP side)	assumes NFP side	3 to 5	3 to 5	Hard Turn NFP Side	100			Inside Scan Dash Gauge	50
REACT TO MISSILE (NFP side)	Movement to Cover		120	120	Outside Scan Regular	70	Inside Scan Dash Gauges	30	Map/Doc Referencing	90
REACT TO GUNFIRE	Detect Threat		5	5	Rapid Outside Scanning	90	Inside Scan Dash Gauges	10	Rapid Outside Scanning	90
REACT TO GUNFIRE	Movement to Cover		120	120	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	70
REACT TO GUNFIRE	CONTACT Report		120-180	120-180	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Map/Doc Referencing	90
REACT TO FIGHTER ATTACK	Detect Threat		12	12	Rapid Outside Scanning	90	Inside Scan Dash Gauges	10	Rapid Outside Scanning	30
REACT TO FIGHTER ATTACK	CONTACT Report		120-180	120-180	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Map/Doc Referencing	90
SHUTDOWN	Post-landing Shutdown		180-240	180-240	Outside Scan Regular	10	Inside Scan Dash Gauges	90	Outside Scan Regular	10
SHUTDOWN	Close Cabin Door		10	10	Outside Scan Regular	10	Inside Scan Dash Gauges	90	Outside Scan Regular	10
SHUTDOWN	Egress AC		60-120	60-120	AC Egress	100			AC Egress	100
RETASKING	Receive New Tasking	Received in-flight	600	600	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	30
RETASKING	Conduct Enroute Flight		depends	depends	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
RETASKING	Conduct Detailed Planning	as part of enroute flight	300	300	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	30

Non-Flying Pilot (NFP for postures 2 and 3) and Flight Engineer (FE):

Block	Task	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3
PRE-FLIGHT	Load Mission Kit					Walking	80	Equipment Handling Outside	20	
PRE-FLIGHT	Mission Kit Check (Hook)					Sling Hook-up Manual	100			
PRE-FLIGHT	Open and Ingress AC					Door Opening Outside	100			
PRE-FLIGHT	Start-up/Last Chance Insp.	Map/Doc Referencing	50	CDU/AMS Use	30	Start-up/Last Chance Insp.	100			
PRE-FLIGHT	Post-start Checks	Map/Doc Referencing	50	CDU/AMS Use	30	Equipment Handling Inside	100			
PRE-FLIGHT	Pre-departure Checks	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAXI (Field)	Pre-taxi Checks	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100			
TAXI (Field)	Take-off to Hover Regular	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAXI (Field)	Taxi Field	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAXI (Airport)	Pre-Takeoff Checks	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100			
TAXI (Airport)	Take-off to Hover Regular	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAXI (Airport)	Post-Take off Checks	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAXI (Airport)	Pre-taxi Checks	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100			
TAXI (Airport)	Taxi to Hold Area	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAXI (Airport)	Land at Hold Area	Inside Scan Dash Gauges	50			Scan Regular Landing	100			
TAXI (Airport)	Obtain IFR Clearance					Scan Regular Take-off	100			
TAKE-OFF (Hover)	Pre-Takeoff Checks	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100			
TAKE-OFF (Hover)	Take-off to Hover Regular	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAKE-OFF (Hover)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100			
TAKE-OFF (Hover)	Post-Take off Checks	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAKE-OFF (No Hover)	Pre-Takeoff Checks	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100			
TAKE-OFF (No Hover)	Take-off No Hover Regular	Inside Scan Dash Gauges	30			Scan Regular Take-off	100			
TAKE-OFF (No Hover)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100			
TAKE-OFF (No Hover)	Post-Take off Checks	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TAKE-OFF (Confined)	Pre-Takeoff Checks	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100			
TAKE-OFF (Confined)	Take-off Confined Area	Inside Scan Dash Gauges	25			Scan Confined	100			
TAKE-OFF (Confined)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100			
TAKE-OFF (Confined)	Post-Take off Checks	Inside Scan Dash Gauges	50			Scan Regular Take-off	100			
TRANSITION (Regular, Non-tact., Single)	Transition to Forward Flt (Reg)	Inside Scan Dash Gauges	40			Scan Regular Take-off	100			
TRANSITION (Regular, Non-tact., Single)	Close Cabin Door	Inside Scan Dash Gauges	50			Door Closing Seated	100			
TRANSITION (Regular, Non-tact., Single)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100			
TRANSITION (Regular, Non-tact., Single)	Non-tactical Climb	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100			
TRANSITION (Regular, Non-tact., Single)	Transition to Level Flt	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Scan Seated Door Closed	100			
TRANSITION (Confined, Non-tact., Single)	Transition to Fwd Flt (Confined)	Inside Scan Dash Gauges	50			Scan Confined	100			
TRANSITION (Confined, Non-tact., Single)	Close Cabin Door	Inside Scan Dash Gauges	50			Door Closing Seated	100			
TRANSITION (Confined, Non-tact., Single)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100			
TRANSITION (Confined, Non-tact., Single)	Non-tactical Climb	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100			
TRANSITION (Confined, Non-tact., Single)	Transition to Level Flt	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Scan Seated Door Closed	100			
TRANSITION (Reg. Non-tact., Sect. Ld)	Transition to Sect. Mov't Lead	Map/Doc Referencing	40	CDU/AMS Use	10	Scan Seated Door Closed	100			
TRANSITION (Reg. Non-tact., Sect. #2)	Transition to Sect. Mov't #2	Map/Doc Referencing	20	CDU/AMS Use	10	Scan Seated Door Closed	100			
TRANSITION (Confined Non-tact., Sect. Ld)	Trans. to Sect. Mov't Lead Confined	Map/Doc Referencing	40	CDU/AMS Use	10	Scan Seated Door Closed	100			
TRANSITION (Confined Non-tact., Sect. #2)	Trans. to Sect. Mov't #2 Confined	Map/Doc Referencing	20	CDU/AMS Use	10	Scan Seated Door Closed	100			

Block	Task	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3	FE Post 3 %
TRANSITION (Zoom Climb)	Transition to Fwd Flt (Zoom)	Inside Scan Dash Gauges	40			Scan Regular Take-off	100				
TRANSITION (Zoom Climb)	Close Cabin Door	Inside Scan Dash Gauges	50			Door Closing Seated	100				
TRANSITION (Zoom Climb)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100				
TRANSITION (Zoom Climb)	Zoom Climb (6000')	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
TRANSITION (Other Climbs)	Transition to Forward Flt (Reg)	Inside Scan Dash Gauges	40			Scan Regular Take-off	100				
TRANSITION (Other Climbs)	Close Cabin Door	Inside Scan Dash Gauges	50			Door Closing Seated	100				
TRANSITION (Other Climbs)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100				
TRANSITION (Other Climbs)	"insert other climb type below"										
TRANSITION (Other Climbs)	Transition to Level Flt	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
TRANSITION (Climb to Contour Flt)	Non-tactical Climb to Contour (<100')	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
TRANSITION (Flat Ascent Climb)	Flat Ascent Climb (100-200')	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
TRANSITION (Spiral Climb)	Spiral Climb (3000')	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
NAVIGATION	Route Planning	CDU/AMS Use	20	Map/Doc Referencing	60	Scan Regular Landing	100				
NAVIGATION	Enroute Navigation	Map/Doc Referencing	35	CDU/AMS Use	15	Scan Seated Door Closed	100				
RE-BROADCASTING	Set up Comms for Re-bro	CDU/AMS Use	90			Transit Seated	50	Scan Seated Door Closed	50		
RE-BROADCASTING	Conduct Re-bro in Loiter	CDU/AMS Use	90			Transit Seated	75	Scan Seated Door Closed	25		
TRANSIT TYPE (Regular VFR)	Transit Regular VFR	Inside Scan Dash Gauges	20			Transit Seated	75	Scan Seated Door Closed	25		
TRANSIT TYPE (Regular IFR)	Transit Regular IFR	Inside Scan Dash Gauges	20			Transit Seated	75	Scan Seated Door Closed	25		
TRANSIT TYPE (Contour)	Transit Contour	Map/Doc Referencing	32	CDU/AMS Use	8	Transit Seated	75	Scan Seated Door Closed	25		
TRANSIT TYPE (NOE)	Transit NOE	Inside Scan Dash Gauges	60			Scan Regular Landing	100				
LANDING APPROACH (Straight Term. Nav.)	Review Terminal Navigation	Map/Doc Referencing	60			Scan Seated Door Closed	100				
LANDING APPROACH (Straight Term. Nav.)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100				
LANDING APPROACH (Straight Term. Nav.)	Conduct Term. Nav. Straight	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
LANDING APPROACH (Straight Term. Nav.)	Final Approach	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
LANDING APPROACH (Straight Term. Nav.)	Cabin Door Opening	Inside Scan Dash Gauges	50			Door Opening Inside	100				
LANDING APPROACH (Straight Term. Nav.)	"insert a landing type below"										
LANDING APPROACH (Spiral Term. Nav.)	Review Terminal Navigation	Map/Doc Referencing	60			Scan Seated Door Closed	100				
LANDING APPROACH (Spiral Term. Nav.)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100				
LANDING APPROACH (Spiral Term. Nav.)	Conduct Term. Nav. Spiral	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
LANDING APPROACH (Spiral Term. Nav.)	Final Approach	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
LANDING APPROACH (Spiral Term. Nav.)	Cabin Door Opening	Inside Scan Dash Gauges	50			Door Opening Inside	100				
LANDING APPROACH (Spiral Term. Nav.)	"insert a landing type below"										
LANDING TYPE (Hover Regular)	Landing Hover Regular	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
LANDING TYPE (Tactical Regular)	Landing Tactical Regular	Inside Scan Dash Gauges	30			Scan Regular Landing	100				
LANDING TYPE (Hover Confined)	Landing Hover Confined	Inside Scan Dash Gauges	20			Scan Confined	100				
LANDING TYPE (Hover Sloped)	Landing Sloped	Inside Scan Dash Gauges	30			Scan Sloped Landing	100				
LANDING TYPE (Hover Obscurred)	Landing Visually Obscurred	Inside Scan Dash Gauges	30			Scan Confined	100				
PICK-UP (Troops)	Troops	CDU/AMS Use	25	Map/Doc Referencing	25	Walking	95	Equipment Handling Outside	5		
PICK-UP (Troops)	Secure Troops/Equip in AC	CDU/AMS Use	50			Equipment Handling Inside	100				
PICK-UP (Slung Load, Manual)	Landing Slide to Sling	Inside Scan Dash Gauges	10			Scan during Slide to Sling	100				
PICK-UP (Slung Load, Manual)	Hook up Slung Loads FE Manual	Inside Scan Dash Gauges	10			Walking	50	Sling Hook-up Manual	50		
PICK-UP (Slung Load, Manual)	Take-off with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	100				

Block	Task	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3	FE Post 3 %
PICK-UP (Slung Load, Manual)	Climb with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	100				
PICK-UP (Slung Load, Manual)	2-Full Check NFP Pilot	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
PICK-UP (Slung Load, Manual)	Transition to Fwd Flt (Slung Reg)	Inside Scan Dash Gauges	40			Scan Slung Load	100				
PICK-UP (Slung Load, Manual)	Control AC with Slung Load	Inside Scan Dash Gauges	90			Scan Slung Load	100				
PICK-UP (Slung Load, Manual)	Transit with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	20	Scan Regular Landing	80		
PICK-UP (Slung Load, Manual,Confined)	Landing Slide to Sling	Inside Scan Dash Gauges	10			Scan during Slide to Sling	100				
PICK-UP (Slung Load, Manual,Confined)	Hook up Slung Loads FE Manual	Inside Scan Dash Gauges	10			Walking	50	Sling Hook-up Manual	50		
PICK-UP (Slung Load, Manual,Confined)	Take-off with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	100				
PICK-UP (Slung Load, Manual,Confined)	2-Full Check NFP Pilot	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
PICK-UP (Slung Load, Manual,Confined)	Climb with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	100				
PICK-UP (Slung Load, Manual,Confined)	Transition to Fwd Flt (Slung Confined)	Inside Scan Dash Gauges	50			Scan Confined	80	Scan Slung Load	20		
PICK-UP (Slung Load, Manual,Confined)	Control AC with Slung Load	Inside Scan Dash Gauges	90			Scan Slung Load	100				
PICK-UP (Slung Load, Manual,Confined)	Transit with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	20	Scan Regular Landing	80		
PICK-UP (Slung Load, TAMS)	Transition to Hover	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
PICK-UP (Slung Load, TAMS)	Slung Loads TAMS	Inside Scan Dash Gauges	10			Scan Slung Load	100				
PICK-UP (Slung Load, TAMS)	Take-off with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	100				
PICK-UP (Slung Load, TAMS)	Climb with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	100				
PICK-UP (Slung Load, TAMS)	Transition to Fwd Flt (Slung Reg)	Inside Scan Dash Gauges	40			Scan Slung Load	100				
PICK-UP (Slung Load, TAMS)	Control AC with Slung Load	Inside Scan Dash Gauges	90			Scan Slung Load	100				
PICK-UP (Slung Load, TAMS)	Transit with Slung Load	Inside Scan Dash Gauges	50			Scan Slung Load	20	Scan Regular Landing	80		
PICK-UP (FARP)	FARP Pick-ups	Inside Scan Dash Gauges	5			Walking	50	Start-up/Last Chance Insp.	50		
PICK-UP (SAR Hoist Stokes Litter)	SAR Hoist Stokes Litter										
PICK-UP (SAR Hoist SAR Tech)	SAR Hoist SAR Tech										
DROP-OFF (Troops)	Landing Tactical Regular	Inside Scan Dash Gauges	30			Scan Troops on Sill	100				
DROP-OFF (Troops)	Troops	CDU/AMS Use	40	Inside Scan Dash Gauge	10	Equipment Handling Inside	50	Equipment Handling Outside	50		
DROP-OFF (Slung Load, Pilot Drop)	Transition to Hover	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
DROP-OFF (Slung Load, Pilot Drop)	Slung Loads Drop (Pilot)	Inside Scan Dash Gauges	10			Scan Slung Load	100				
DROP-OFF (Slung Load, Manual)	Slung Load Landing	Inside Scan Dash Gauges	10			Scan Slung Load	100				
DROP-OFF (Slung Load, Manual)	Slung Load Unhook Manual	Inside Scan Dash Gauges	50			Sling Unhook Manual	100				
DROP-OFF (SAR Hoist SAR Tech)	SAR Hoist SAR Tech										
DROP-OFF (SAR Hoist Stokes Litter)	SAR Hoist Stokes Litter										
DROP-OFF (SAR Hoist Billy Pugh)	SAR Hoist Billy Pugh										
DROP-OFF (Troops, Rappelling)	Rappelling Troops										
CHECKS (2-Full FE)	2-Full Check FE	Inside Scan Dash Gauges	50			2-Full Check	100				
CHECKS (2-Full NFP)	2-Full Check NFP Pilot	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
CHECKS (SAR)	SAR Check										
RECCE (MX-15)	Plan ISR	Inside Scan Dash Gauges	40			Scan Seated Door Closed	100				
RECCE (MX-15)	Conduct ISR Profile	MX-15 Use	75	CDU/AMS Use	10	Transit Seated	50	Scan Seated Door Closed	50		
OBS MANEUVER (Pop up)	Plan Observation Maneuver	Map/Doc Referencing	60	CDU/AMS Use	20	Scan Confined	100				

Block	Task	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3	FE Post 3 %
OBS MANEUVER (Pop up)	Execute Obs Maneuver					Scan Confined	100				
OBS MANEUVER (Pop up)	Assess/Record/Communicate	Map/Doc Referencing	45	CDU/AMS Use	45	Scan Confined	100				
OBS MANEUVER (Pop up)	Reposition AC	Map/Doc Referencing	10			Scan Confined	100				
COMBAT ATTK (Door Guns)	ISR In-bound to TIC	Map/Doc Referencing	5	CDU/AMS Use	5	Scan Regular Landing	100				
COMBAT ATTK (Door Guns)	ISR Observation	MX-15 Use	50			Scan Regular Landing	100				
COMBAT ATTK (Door Guns)	Scan and ID Targets	MX-15 Use	33	Outside Wide Scan	33	Door Gunnery	100				
COMBAT ATTK (Door Guns)	Gunnery Attack Run			Outside Wide Scan	50	Door Gunnery	100				
COMBAT ATTK (Door Guns)	Run out and Turn for each Approach	Inside Scan Dash Gauges	20	Outside Wide Scan	20	Door Gunnery	100				
REACT TO MISSILE (FP side)	Detect Threat					Scan Seated Door Closed	100				
REACT TO MISSILE (FP side)	Assess Threat (FP side)	CDU/AMS Use	50			Scan Seated Door Closed	100				
REACT TO MISSILE (FP side)	Movement to Cover	Inside Scan Dash Gauges	10			Scan Seated Door Closed	100				
REACT TO MISSILE (NFP side)	Detect Threat					Scan Seated Door Closed	100				
REACT TO MISSILE (NFP side)	Assess Threat (NFP side)	CDU/AMS Use	50			Scan Seated Door Closed	100				
REACT TO MISSILE (NFP side)	Movement to Cover	Inside Scan Dash Gauges	10			Scan Seated Door Closed	100				
REACT TO GUNFIRE	Detect Threat	Inside Scan Dash Gauges	10			Scan Confined	100				
REACT TO GUNFIRE	Movement to Cover	Inside Scan Dash Gauges	30			Scan Confined	100				
REACT TO GUNFIRE	CONTACT Report	Outside Scan Regular	10			Scan Regular Landing	100				
REACT TO FIGHTER ATTACK	Detect Threat	Inside Scan Dash Gauges	70			Scan Regular Take-off	100				
REACT TO FIGHTER ATTACK	CONTACT Report	Outside Scan Regular	10			Scan Regular Landing	100				
SHUTDOWN	Post-landing Shutdown	Inside Scan Dash Gauges	90			Equipment Handling Inside	70	Scan Regular Landing	10	2-Full Check	20
SHUTDOWN	Close Cabin Door	Inside Scan Dash Gauges	90			Door Closing Outside	100				
SHUTDOWN	Egress AC					Walking	100				
RETASKING	Receive New Tasking	Map/Doc Referencing	40	CDU/AMS Use	30	Transit Seated	50	Scan Seated Door Closed	50		
RETASKING	Conduct Enroute Flight	Map/Doc Referencing	40	CDU/AMS Use	10	Scan Seated Door Closed	50	Transit Seated	50		
RETASKING	Conduct Detailed Planning	Map/Doc Referencing	40	CDU/AMS Use	30	Scan Seated Door Closed	50	Transit Seated	50		

Annex B: Summary Physical Demands Analysis

Postures

Flight Engineer Neck Posture

Table 31 –Flight Engineer Average Neck Posture - Day

Posture Sequence	Flexion (degrees)	Extension (degrees)	Left Axial Rotation (degrees)	Right Axial Rotation (degrees)	Left Lateral Bend (degrees)	Right Lateral Bend (degrees)
2 Full Check	-11.05	9.01	7.54	-26.92	-6.62	7.61
Door Closing Outside	-16.32	1.48	7.37	-22.11	-2.61	11.22
Door Closing Seated	-21.52	NA	1.13	-32.92	-8.05	12.10
Door Opening Inside	-18.19	2.10	11.87	-25.30	-8.78	6.03
Door Opening Outside	-13.51	3.56	7.41	-23.59	-3.07	7.99
Equipment Handling Inside	-11.32	1.95	3.61	-25.15	-6.18	8.56
Equipment Handling Outside	-13.52	4.81	12.03	-24.10	-8.19	13.23
Ingress	-22.88	0.55	6.17	-8.24	-6.14	9.04
Scan Confined	-13.45	7.84	23.81	-43.97	-11.11	8.98
Scan During Slide to Sling	-12.73	7.76	18.08	-13.12	-7.21	15.66
Scan NFP Side	-16.11	9.87	31.54	-28.30	-8.40	10.69
Scan Regular Landing	-16.79	3.90	25.93	-45.48	-9.76	12.33
Scan Regular Take Off	-15.90	13.96	18.75	-34.83	-6.22	8.75
Scan Seated Door Closed	-22.60	NA	31.18	-41.73	-20.23	13.07
Scan Slope Landing	-15.50	13.37	22.65	-35.60	-5.87	7.47
Scan Slung Load	-25.05	4.04	24.01	-30.71	-9.57	11.04
Scan Troops on Sill	-11.27	7.38	24.87	-51.31	-8.85	9.39
Sling Hook Up Manual	-19.98	5.43	11.67	-26.22	-9.86	11.95
Sling Unhook Manual	-18.65	13.96	17.95	-24.41	-11.30	11.93
Start Up Last Chance Insp.	-14.24	5.18	12.47	-23.31	-6.03	7.28
Transit Seated	-13.37	3.24	11.04	-23.97	-2.04	3.99
Walking	-11.51	NA	NA	-14.50	-1.65	4.17

Table 32: Flight Engineer Average Neck Posture - Night

Posture Sequence	Flexion (degrees)	Extension (degrees)	Left Axial Rotation (degrees)	Right Axial Rotation (degrees)	Left Lateral Bend (degrees)	Right Lateral Bend (degrees)
2 Full Check	-12.37	11.81	14.41	-17.00	-6.19	10.10
Door Closing Outside	-14.62	2.18	28.11	-11.83	-9.14	9.02
Door Closing Seated	-18.21	1.83	1.36	-19.11	-7.64	7.74
Door Opening Inside	-11.08	8.63	14.05	-29.44	-5.97	7.17
Door Opening Outside	-15.66	NA	13.66	-11.20	-6.97	5.88
Equipment Handling Inside	-14.70	4.84	11.53	-17.13	-6.59	10.54
Equipment Handling Outside	-12.78	3.12	14.40	-11.27	-8.30	9.02
Ingress	-23.06	NA	9.06	-6.89	-7.85	8.00
Scan Confined	-28.23	9.88	23.73	-36.75	-11.47	17.85
Scan During Slide to Sling	-17.41	10.22	40.03	-19.57	-10.11	4.84
Scan NFP Side	-19.07	4.03	36.94	-44.82	-14.11	18.65
Scan Regular Landing	-22.30	8.25	34.07	-39.02	-8.49	16.76
Scan Regular Take Off	-23.10	12.51	23.85	-39.79	-11.95	8.83
Scan Seated Door Closed	-15.66	6.22	21.88	-50.65	-5.98	14.22
Scan Slope Landing	-31.68	12.81	24.26	-28.72	-9.37	10.39
Scan Slung Load	-38.26	8.03	29.37	-24.86	-9.75	14.69
Scan Troops on Sill	-14.84	10.40	37.11	-36.54	-11.17	11.96
Sling Hook Up Manual	-19.52	8.80	15.51	-25.89	-13.46	12.94
Sling Unhook Manual	-18.09	7.31	22.61	-16.59	-7.77	8.37
Start Up Last Chance Insp.	-14.26	5.90	13.95	-17.17	-4.88	6.78
Transit Seated	-12.16	5.07	20.72	-37.03	-6.25	7.29
Walking	-9.49	1.44	11.44	-16.87	-3.81	3.73

Flight Engineer Percent of Time Spent in Posture Zones

Table 33: Flight Engineer- percent of time spent in posture zones (highlighted cell represent highest value for that joint motion)

	Day										Night									
	Flexion/Extension				Lat Bend			Rotation			Flexion/Extension				Lat Bend			Rotation		
Posture Sequence	>10	10 to -10	-10 to -30	<-30	<15	15 to 30	>30	<10	10 to 40	>40	>10	10 to -10	-10 to -30	<-30	<15	15 to 30	>30	<10	10 to 40	>40
2 Full Check	7.67%	50.01%	40.87%	1.45%	92.88%	7.12%	0.00%	25.33%	62.06%	12.61%	14.08%	43.63%	41.99%	0.30%	82.44%	16.60%	0.95%	36.00%	59.09%	4.90%
Door Closing Outside	0.00%	28.95%	69.67%	1.38%	74.01%	25.09%	0.90%	30.18%	63.72%	6.10%	0.00%	30.82%	69.18%	0.00%	87.01%	12.99%	0.00%	39.55%	50.39%	10.06%
Door Closing Seated	0.00%	3.70%	83.05%	13.25%	79.90%	15.58%	4.52%	15.37%	59.50%	25.13%	0.00%	18.71%	71.01%	10.28%	80.92%	18.52%	0.57%	47.66%	47.73%	4.61%
Door Opening Inside	0.00%	29.83%	59.26%	10.90%	90.20%	9.80%	0.00%	36.99%	51.45%	11.56%	5.41%	57.19%	37.14%	0.26%	96.33%	3.67%	0.00%	28.95%	40.93%	30.12%
Door Opening Outside	0.00%	38.37%	61.63%	0.00%	94.19%	5.81%	0.00%	37.38%	50.80%	11.82%	0.00%	24.26%	75.74%	0.00%	100.00%	0.00%	0.00%	47.19%	52.81%	0.00%
Equipment Handling Inside	0.00%	54.98%	44.06%	0.97%	88.57%	11.43%	0.00%	20.70%	61.74%	17.56%	0.59%	35.76%	63.65%	0.00%	80.39%	11.58%	8.04%	32.57%	64.19%	3.24%
Equipment Handling Outside	1.64%	58.17%	39.11%	1.08%	67.12%	31.12%	1.77%	26.55%	61.74%	11.70%	0.00%	44.01%	55.99%	0.00%	73.31%	26.69%	0.00%	53.72%	46.28%	0.00%
Ingress	0.00%	4.05%	78.32%	17.63%	91.20%	8.80%	0.00%	63.09%	36.91%	0.00%	0.00%	10.95%	59.48%	29.58%	84.34%	15.66%	0.00%	63.47%	35.98%	0.55%
Scan Confined	6.44%	52.13%	31.03%	10.39%	76.11%	23.89%	0.00%	11.73%	47.53%	40.74%	7.84%	38.43%	26.29%	27.44%	63.48%	30.51%	6.01%	20.34%	41.52%	38.14%
Scan During Slide to Sling	7.63%	39.34%	50.24%	2.79%	75.23%	20.72%	4.05%	33.45%	49.89%	16.67%	8.21%	44.18%	36.39%	11.23%	79.74%	20.00%	0.27%	19.07%	22.52%	58.41%
Scan NFP Side	7.22%	46.47%	39.30%	7.00%	82.02%	17.98%	0.00%	17.37%	50.01%	32.62%	2.15%	53.36%	26.43%	18.06%	52.72%	32.06%	15.22%	12.70%	35.44%	51.86%
Scan Regular Landing	0.29%	45.79%	38.78%	15.14%	72.95%	22.47%	4.58%	14.33%	38.68%	46.99%	7.90%	44.70%	24.29%	23.12%	70.33%	20.55%	9.12%	23.38%	29.76%	46.86%
Scan Regular Take Off	15.14%	38.66%	37.16%	9.04%	87.77%	12.23%	0.00%	25.92%	39.22%	34.86%	23.68%	37.45%	21.81%	17.06%	68.42%	25.87%	5.71%	28.70%	28.76%	42.54%
Scan Seated Door Closed	0.00%	8.29%	73.53%	18.18%	53.89%	36.36%	9.74%	10.82%	31.31%	57.87%	2.12%	37.03%	55.48%	5.37%	66.44%	28.06%	5.50%	13.47%	35.22%	51.31%
Scan Slope Landing	10.77%	43.63%	37.52%	8.09%	90.12%	9.88%	0.00%	13.14%	61.50%	25.35%	12.19%	16.31%	24.46%	47.03%	75.88%	21.96%	2.16%	28.81%	42.17%	29.03%
Scan Slung Load	0.00%	11.83%	54.80%	33.38%	74.10%	25.90%	0.00%	20.48%	51.13%	28.38%	4.48%	9.86%	16.58%	69.08%	62.82%	26.69%	10.50%	31.92%	48.26%	19.82%
Scan Troops on Sill	10.70%	65.41%	23.54%	0.34%	68.34%	31.66%	0.00%	12.17%	40.92%	46.92%	15.76%	46.06%	33.75%	4.42%	67.58%	31.95%	0.47%	23.30%	32.13%	44.57%
Sling Hook Up Manual	2.29%	26.68%	52.43%	18.60%	68.35%	30.57%	1.08%	26.10%	55.86%	18.04%	5.74%	30.07%	47.05%	17.14%	64.31%	27.66%	8.03%	30.64%	55.76%	13.60%
Sling Unhook Manual	5.20%	21.03%	60.71%	13.05%	66.84%	31.02%	2.14%	30.33%	56.10%	13.57%	6.16%	35.83%	46.28%	11.73%	86.44%	13.25%	0.31%	35.20%	52.85%	11.95%
Start Up Last Chance Insp.	1.84%	48.01%	42.82%	7.33%	91.17%	8.49%	0.34%	32.37%	54.93%	12.70%	4.12%	50.61%	39.90%	5.36%	93.55%	5.94%	0.52%	35.16%	62.25%	2.59%
Transit Seated	0.00%	33.53%	63.74%	2.73%	98.62%	1.38%	0.00%	54.24%	34.21%	11.55%	0.00%	34.61%	65.39%	0.00%	93.34%	6.66%	0.00%	14.18%	61.75%	24.07%
Walking	0.00%	33.13%	66.87%	0.00%	100.00%	0.00%	0.00%	48.18%	51.82%	0.00%	0.00%	53.16%	46.84%	0.00%	100.00%	0.00%	0.00%	40.00%	60.00%	0.00%

Flying Pilot Neck Posture

Table 34: Flying Pilot Average Neck Posture - Day

Posture	Flexion	Extension (degrees)	Left Axial Rot. (degrees)	Right Axial Rot. (degrees)	Left Lat. Bend (degrees)	Right Lat. Bend (degrees)
AC Egress	-34.45	6.67	14.99	-15.63	-8.10	8.54
AC Ingress	-38.71	7.10	11.27	-22.13	-6.59	10.83
Hard Turn FP Side	-13.92	12.13	18.04	-45.90	-3.91	13.72
Hard Turn NFP Side	-15.51	3.21	36.94	-4.75	-6.44	4.43
Inside Scan Ceiling Switches	-10.36	6.15	41.45	-1.14	-5.35	8.54
Inside Scan Dash Gauges	-28.51	0.00	17.34	-12.79	-8.56	4.63
Outside Scan Chin Bubble	-43.70	0.00	14.91	-15.02	-8.07	9.45
Outside Scan Confined	-27.06	5.42	24.88	-26.67	-6.61	10.84
Outside Scan Regular	-21.29	0.00	18.86	-18.97	-6.12	5.66
Outside Scan Wide	-24.20	0.98	34.12	-29.35	-11.60	10.82
Rapid Scanning	-23.09	0.00	11.89	-31.31	-6.62	9.53
Walking	-12.06	0.00	2.31	-12.73	-1.13	4.27

Table 35: Flying Pilot Average Neck Posture - Night

Posture	Flexion	Extension (degrees)	Left Axial Rot. (degrees)	Right Axial Rot. (degrees)	Left Lat. Bend (degrees)	Right Lat. Bend (degrees)
AC Egress	-31.98	10.26	19.45	-12.49	-9.78	9.75
AC Ingress	-35.66	5.72	21.17	-20.96	-12.76	19.17
Hard Turn FP Side	-15.12	13.13	23.28	-48.81	-2.89	11.82
Hard Turn NFP Side	-13.32	5.40	46.97	-25.18	-9.88	10.01
Inside Scan Ceiling Switches	-14.68	4.88	43.05	-0.22	-7.99	6.18
Inside Scan Dash Gauges	-19.18	0.95	16.17	-8.18	-7.66	7.86
Outside Scan Chin Bubble	-47.86	0.00	4.64	-18.64	-3.43	12.30
Outside Scan Confined	-28.70	0.00	15.28	-31.37	-3.55	16.91
Outside Scan Regular	-17.88	1.73	18.28	-17.21	-4.99	5.63
Outside Scan Wide	-23.29	3.89	31.68	-33.06	-7.67	13.79
Rapid Scanning	-21.69	3.78	12.34	-42.70	-6.94	15.86
Walking	-13.86	0.00	4.80	-12.80	-2.42	3.15

Flying Pilot Percent of Time Spent in Posture Zones

Table 36: Flying Pilot - percent of time spent in posture zones (highlighted cell represent highest value for that joint motion)

	Day										Night									
	Flexion/Extension				Lat. Bend			Rotation			Flexion/Extension				Lat. Bend			Rotation		
Posture	>10	10 to -10	-10 to -30	<-30	<15	15 to 30	>30	<10	10 to 40	>40	>10	10 to -10	-10 to -30	<-30	<15	15 to 30	>30	<10	10 to 40	>40
ACEgress	0.66%	5.18%	32.90%	61.25%	86.64%	13.36%	0.00%	45.78%	49.21%	5.01%	2.07%	9.64%	32.61%	55.68%	77.01%	21.04%	1.95%	40.78%	53.48%	5.74%
ACIngress	0.79%	4.35%	22.62%	72.24%	79.46%	17.99%	2.55%	38.25%	54.67%	7.08%	1.35%	14.06%	26.14%	58.45%	50.72%	35.65%	13.62%	28.98%	59.55%	11.46%
Hard Turn FP Side	14.08%	31.35%	54.57%	0.00%	63.73%	36.27%	0.00%	10.05%	30.26%	59.68%	18.71%	21.33%	59.96%	0.00%	73.12%	25.40%	1.48%	8.51%	27.35%	64.14%
Hard Turn NFP Side	0.00%	34.79%	52.42%	12.78%	100.00%	0.00%	0.00%	27.99%	23.99%	48.02%	3.27%	45.06%	46.26%	5.41%	88.95%	11.05%	0.00%	9.89%	43.60%	46.51%
Inside Scan Ceiling Switches	7.58%	70.79%	19.99%	1.63%	93.06%	6.94%	0.00%	3.01%	39.67%	57.32%	1.37%	46.40%	44.57%	7.66%	93.38%	6.62%	0.00%	1.50%	45.52%	52.98%
Inside Scan Dash Gauges	0.00%	6.94%	46.54%	46.52%	88.47%	11.53%	0.00%	33.04%	66.96%	0.00%	0.00%	14.70%	67.75%	17.54%	81.54%	18.46%	0.00%	45.50%	49.52%	4.98%
Outside Scan Chin Bubble	0.00%	0.00%	37.19%	62.81%	82.35%	13.42%	4.23%	29.52%	70.48%	0.00%	0.00%	0.54%	18.84%	80.62%	71.51%	24.64%	3.85%	22.48%	76.18%	1.34%
Outside Scan Confined	0.00%	22.76%	51.44%	25.80%	66.17%	33.83%	0.00%	26.83%	50.33%	22.84%	0.00%	4.63%	48.60%	46.77%	57.66%	33.44%	8.90%	23.76%	56.22%	20.02%
Outside Scan Regular	0.00%	4.54%	87.69%	7.77%	93.12%	6.88%	0.00%	31.39%	50.23%	18.38%	0.00%	7.41%	92.21%	0.38%	99.05%	0.95%	0.00%	29.64%	63.89%	6.47%
Outside Scan Wide	0.00%	10.64%	62.75%	26.61%	64.19%	35.81%	0.00%	19.57%	43.26%	37.18%	0.00%	17.93%	56.35%	25.72%	68.62%	30.17%	1.21%	17.54%	42.69%	39.77%
Rapid Scanning	0.00%	2.61%	80.52%	16.87%	66.43%	33.27%	0.30%	31.63%	33.90%	34.47%	0.47%	18.89%	68.21%	12.42%	55.00%	42.22%	2.78%	21.00%	25.12%	53.89%
Walking	0.00%	22.53%	77.47%	0.00%	100.00%	0.00%	0.00%	63.74%	36.26%	0.00%	0.00%	33.70%	61.69%	4.61%	100.00%	0.00%	0.00%	62.69%	37.31%	0.00%

Non-Flying Pilot Neck Posture

Table 37: Non Flying Pilot Average Neck Posture - Day

Posture	Flexion (degrees)	Extension (degrees)	Left Axial Rot. (degrees)	Right Axial Rot. (degrees)	Left Lat. Bend (degrees)	Right Lat. Bend (degrees)
AC Egress	-33.40	2.12	27.90	-13.73	-6.31	5.52
AC Ingress	-38.70	3.94	22.30	-19.28	-6.99	10.71
CDU AMS Use	-43.35	1.32	18.76	-32.41	-2.91	6.75
Hard Turn NFP Side	-17.75	4.73	51.66	-32.73	-8.93	4.42
Inside Scan Ceiling Switches	-14.81	8.63	6.43	-37.09	-7.51	13.50
Inside Scan Dash Gauges	-28.12	0.00	9.98	-23.46	-4.10	11.76
Map Doc Referencing	-40.06	0.00	13.00	-22.46	-10.53	10.27
MX15 Use	-67.45	0.00	0.00	-10.85	-0.66	0.58
Outside Scan Confined	-23.14	1.92	32.71	-23.53	-12.17	5.02
Outside Scan Regular	-20.42	4.21	25.70	-25.90	-7.13	5.98
Rapid Scanning	-17.45	7.12	55.31	-37.75	-12.41	8.92
Walking	-12.06	0.00	2.31	-12.73	-1.13	4.27

Table 38: Non Flying Pilot Average Neck Posture - Night

Posture	Flexion (degrees)	Extension (degrees)	Left Axial Rot. (degrees)	Right Axial Rot. (degrees)	Left Lat. Bend (degrees)	Right Lat. Bend (degrees)
AC Egress	-36.05	5.64	32.47	-21.14	-11.20	8.32
AC Ingress	-37.82	9.65	27.54	-22.70	-9.50	6.60
CDU AMS Use	-33.05	0.00	10.12	-26.22	-3.62	2.02
Hard Turn NFP Side	-8.64	3.56	51.42	-16.33	-13.26	2.51
Inside Scan Ceiling Switches	-16.42	6.66	4.67	-33.07	-15.51	8.70
Inside Scan Dash Gauges	-17.66	4.61	11.35	-24.01	-10.44	11.79
Map Doc Referencing	-27.49	0.10	14.83	-17.29	-2.73	4.25
MX15 Use	-22.06	0.00	0.00	-36.59	0.00	3.59
Outside Scan Confined	-25.92	0.31	36.93	-24.99	-16.49	8.13
Outside Scan Regular	-17.77	0.61	33.32	-20.77	-10.81	7.94
Rapid Scanning	-18.73	3.27	55.58	-62.49	-16.58	13.10
Walking	-14.78	0.00	4.80	-13.47	-2.42	3.22

Non-Flying Pilot Percent of Time Spent in Posture Zones

Table 39: Non-Flying Pilot - percent of time spent in posture zones (highlighted cell represent highest value for that joint motion)

	Day										Night									
	Flexion/Extension				Lat. Bend			Rotation			Flexion/Extension				Lat. Bend			Rotation		
Posture	>10	10 to -10	-10 to -30	<-30	<15	15 to 30	>30	<10	10 to 40	>40	>10	10 to -10	-10 to -30	<-30	<15	15 to 30	>30	<10	10 to 40	>40
ACEgress	0.00%	5.21%	31.54%	63.25%	93.82%	6.18%	0.00%	31.98%	49.28%	18.73%	0.18%	10.10%	27.72%	62.00%	75.83%	23.37%	0.80%	28.33%	44.43%	27.23%
ACIngress	0.12%	8.45%	13.97%	77.47%	79.35%	16.58%	4.07%	32.05%	51.15%	16.80%	8.45%	13.80%	26.80%	50.95%	67.39%	22.34%	10.27%	23.42%	45.00%	31.58%
CDU AMS Use	0.00%	1.10%	8.82%	90.07%	87.65%	12.35%	0.00%	18.60%	54.62%	26.78%	0.00%	0.54%	38.27%	61.18%	91.82%	8.18%	0.00%	27.95%	49.99%	22.05%
Hard Turn NFP Side	1.11%	34.82%	47.41%	16.67%	81.17%	18.83%	0.00%	5.51%	43.88%	50.61%	9.14%	60.39%	30.47%	0.00%	75.75%	24.25%	0.00%	12.17%	37.77%	50.06%
Inside Scan Ceiling Switches	16.28%	41.99%	41.61%	0.11%	82.87%	17.13%	0.00%	15.91%	35.99%	48.09%	11.42%	38.89%	47.80%	1.89%	55.42%	33.16%	11.41%	12.98%	54.36%	32.67%
Inside Scan Dash Gauges	0.00%	10.57%	42.90%	46.53%	68.65%	30.95%	0.40%	22.89%	56.11%	21.00%	0.00%	54.37%	31.45%	14.18%	70.99%	27.49%	1.52%	27.54%	65.33%	7.13%
Map Doc Referencing	0.00%	1.04%	13.77%	85.19%	75.56%	24.44%	0.00%	35.43%	47.14%	17.43%	0.00%	5.77%	60.80%	33.43%	98.86%	1.14%	0.00%	30.62%	57.57%	11.82%
MX15 Use	0.00%	0.00%	0.00%	100.00%	100.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%	0.00%	0.00%	0.00%	96.46%	3.54%
Outside Scan Confined	0.00%	7.62%	55.88%	36.50%	76.35%	20.97%	2.68%	31.09%	41.54%	27.37%	0.00%	7.78%	62.77%	29.44%	55.35%	42.47%	2.18%	17.50%	49.90%	32.60%
Outside Scan Regular	0.00%	5.09%	79.83%	15.08%	92.10%	7.90%	0.00%	30.50%	50.62%	18.87%	0.00%	22.39%	66.44%	11.17%	82.51%	17.49%	0.00%	25.21%	40.51%	34.28%
Rapid Scanning	5.82%	30.02%	47.59%	16.57%	68.40%	31.60%	0.00%	13.24%	17.04%	69.72%	0.00%	29.92%	53.98%	16.10%	60.68%	38.69%	0.63%	13.45%	22.58%	63.97%
Walking	0.00%	22.53%	77.47%	0.00%	100.00%	0.00%	0.00%	63.74%	36.26%	0.00%	0.00%	33.70%	61.69%	4.61%	100.00%	0.00%	0.00%	62.69%	37.31%	0.00%

Forces and Moments

Flight Engineer

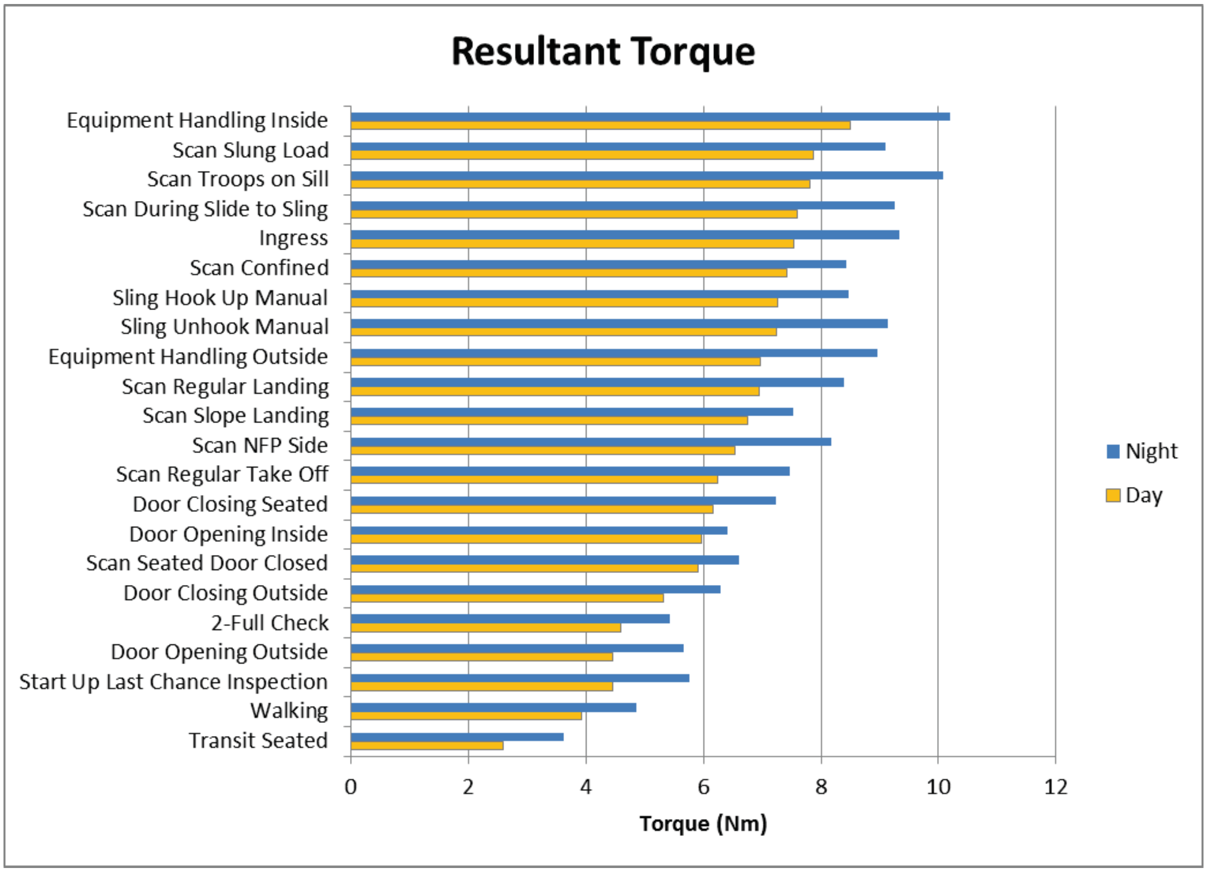

Figure 33: Flight Engineer Average Resultant Torque

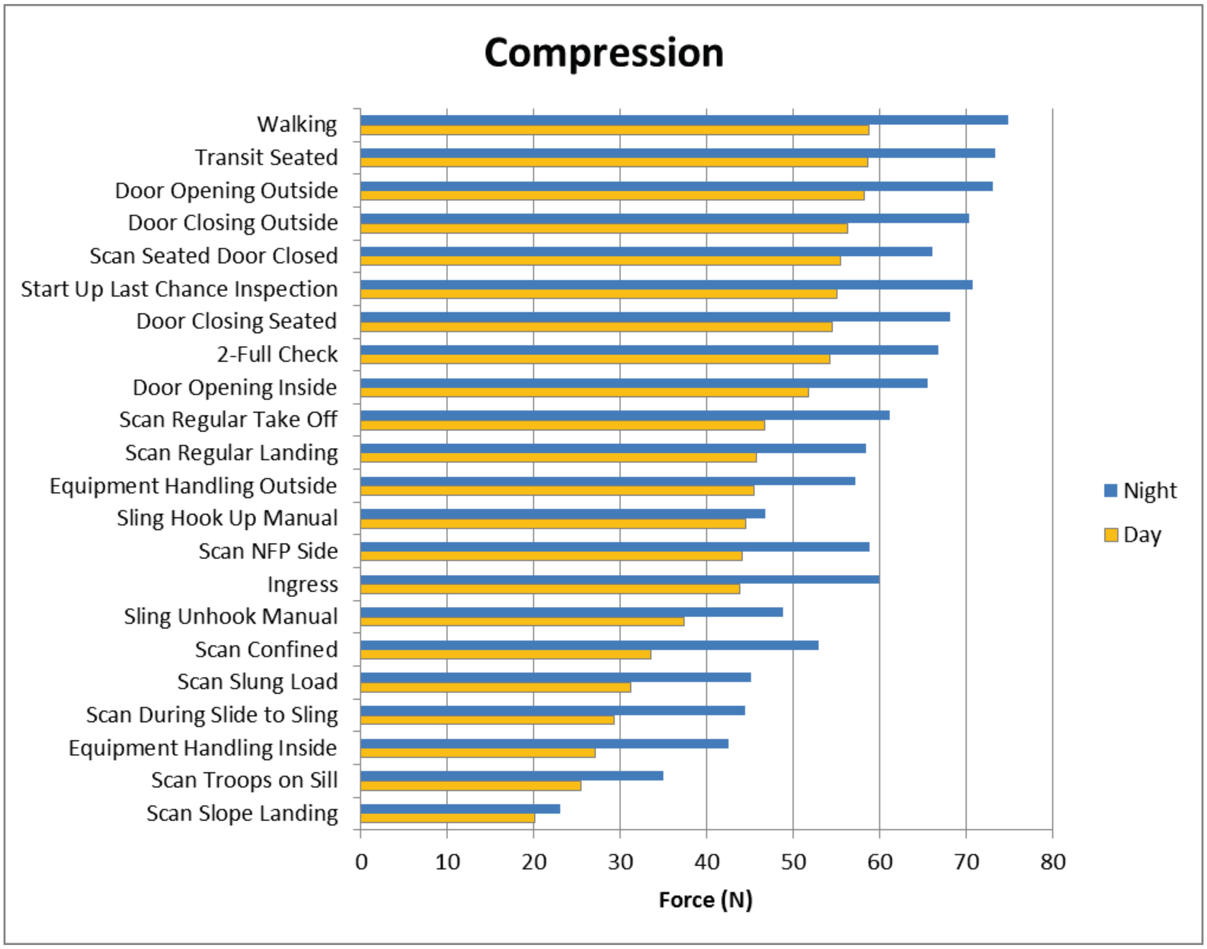

Figure 34: Flight Engineer Average Compression Force

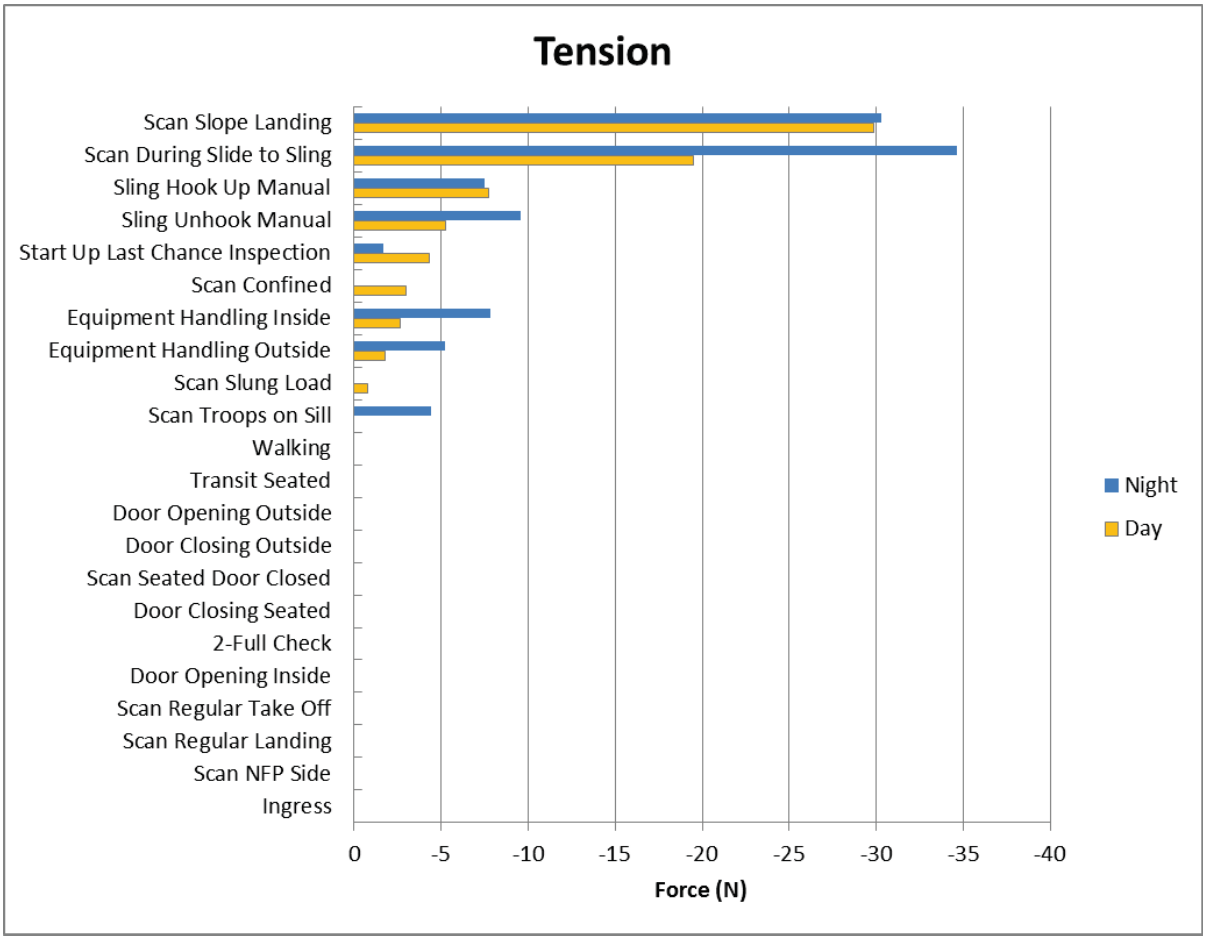

Figure 35: Flight Engineer Average Tension Force

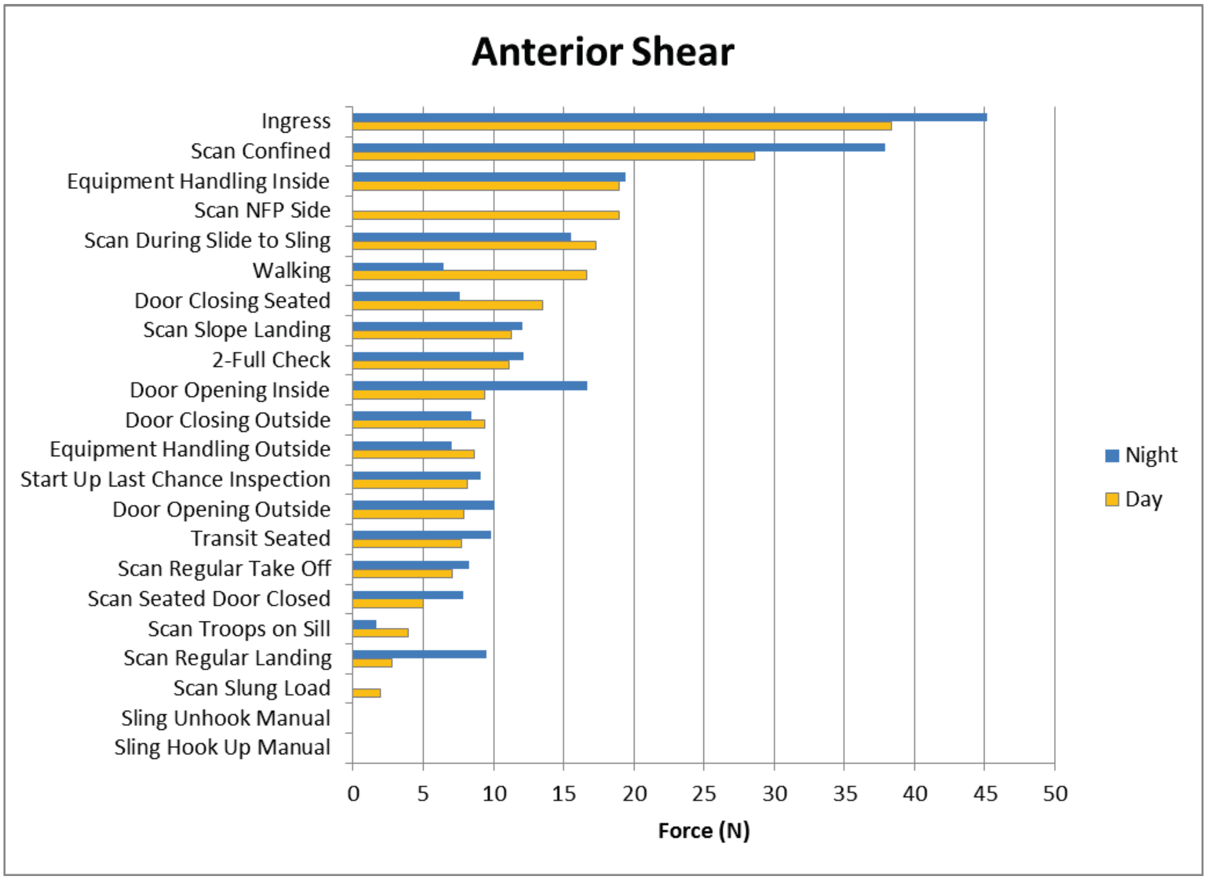

Figure 36: Flight Engineer Average Anterior Shear

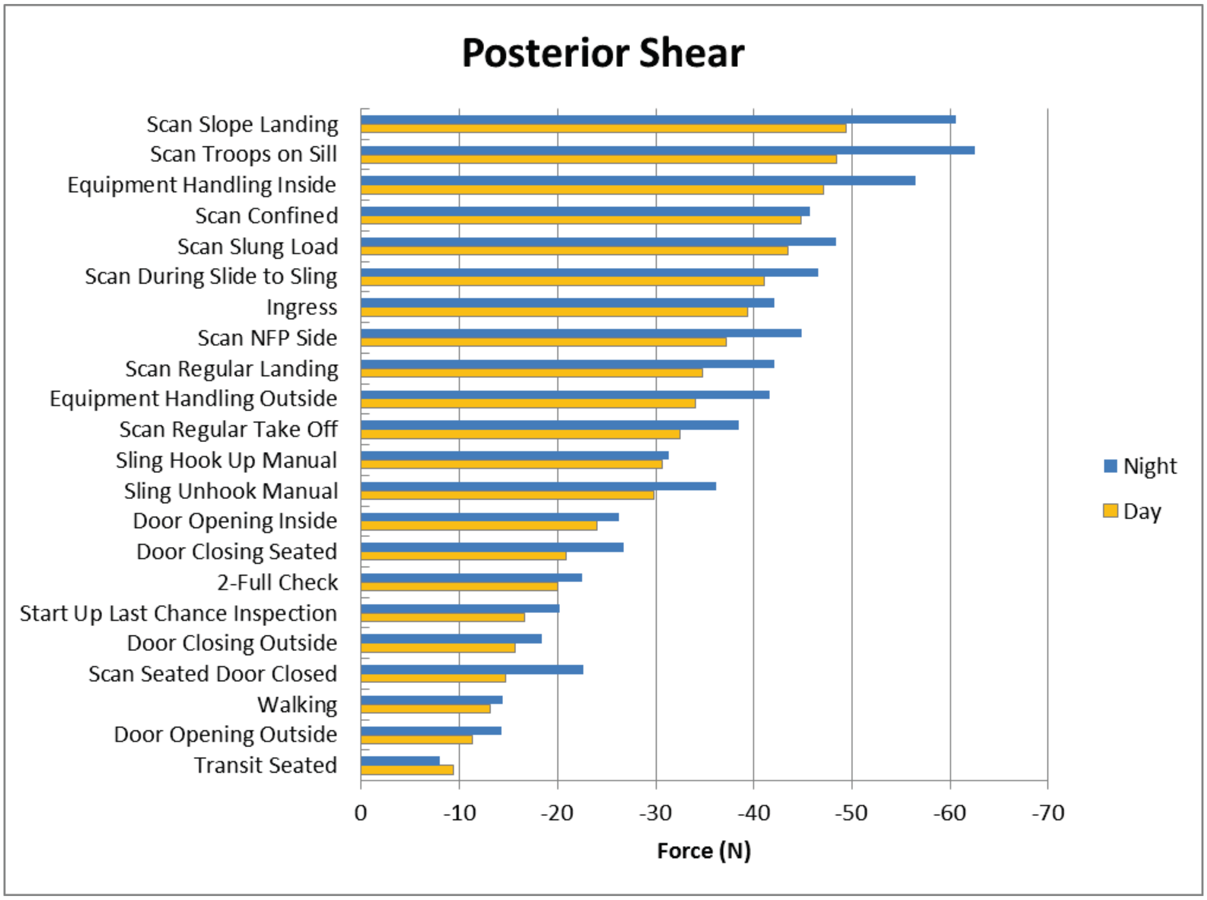

Figure 37: Flight Engineer Average Posterior Shear

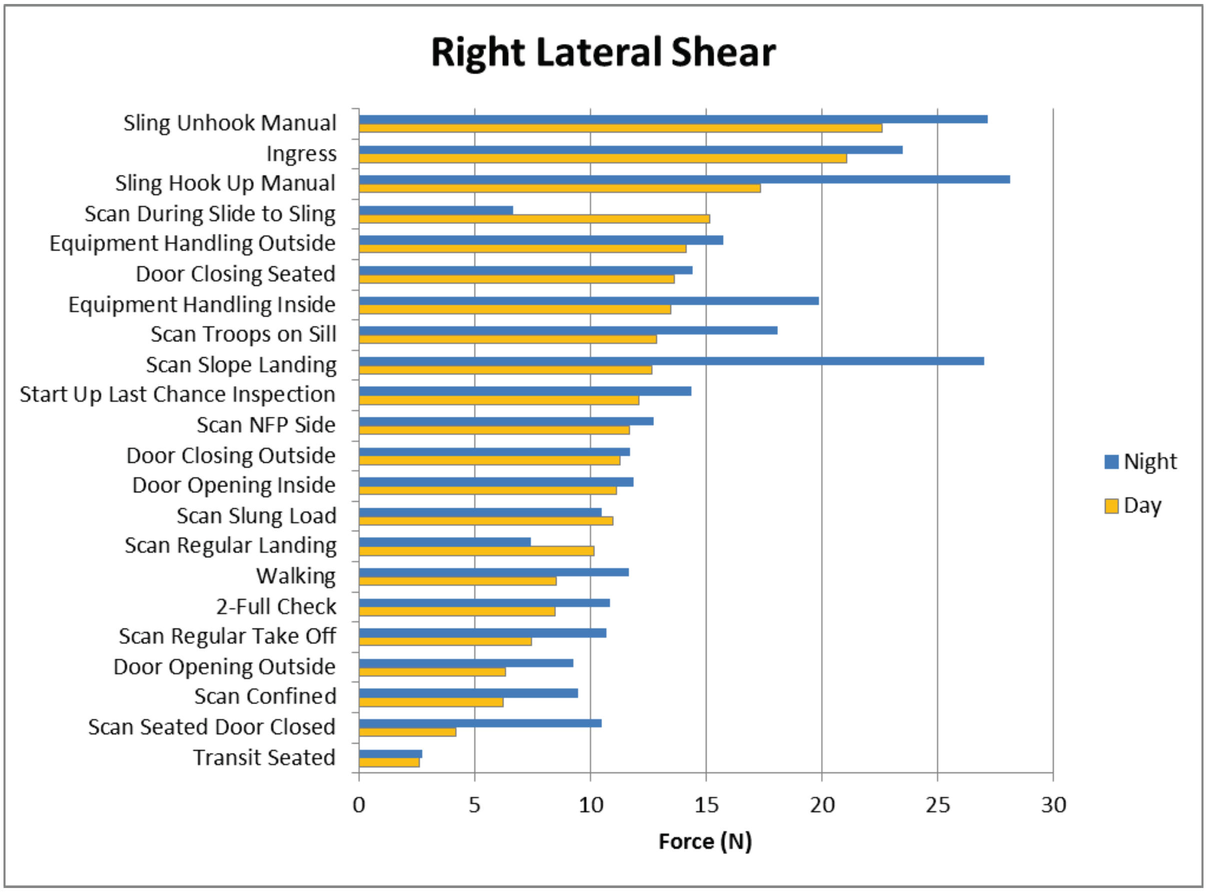

Figure 38: Flight Engineer Average Right Lateral Shear

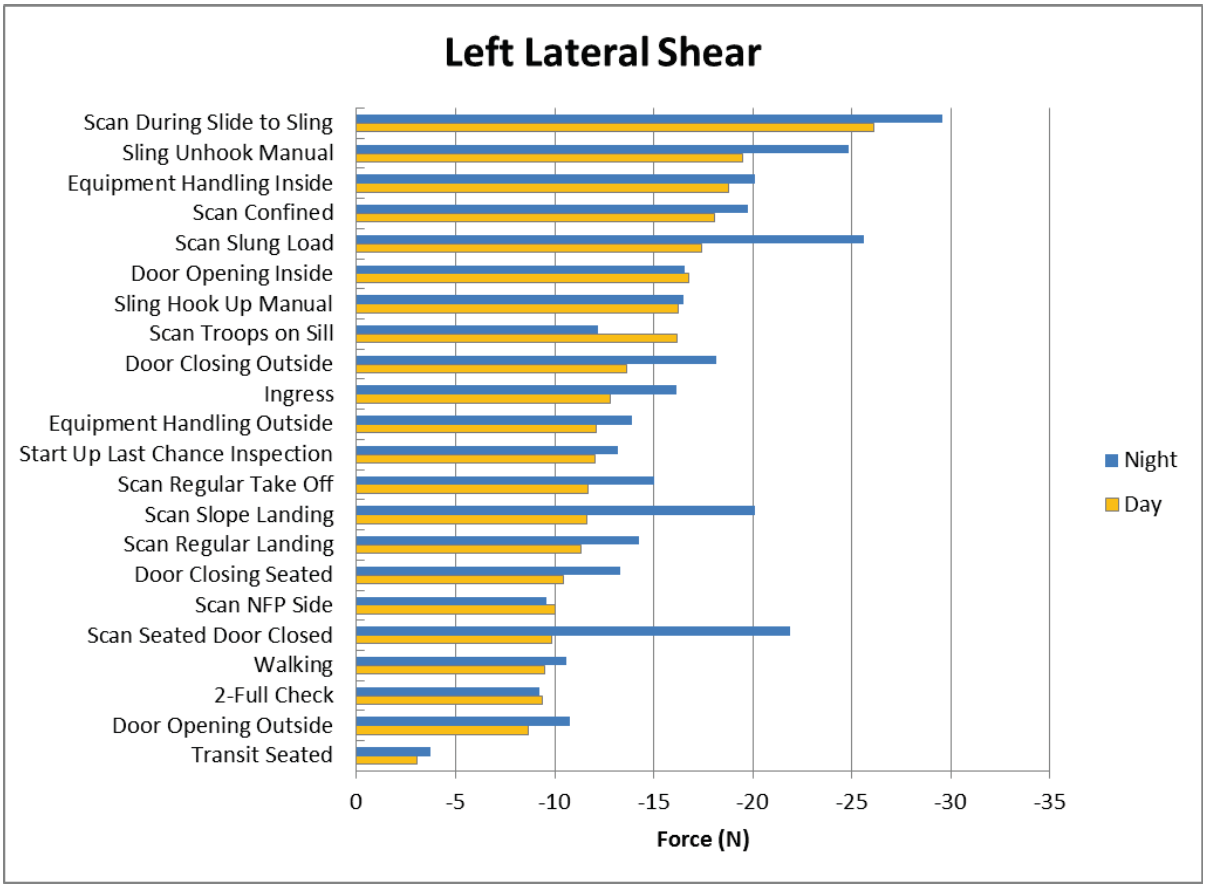

Figure 39: Flight Engineer Average Left Lateral Shear

Flying Pilot

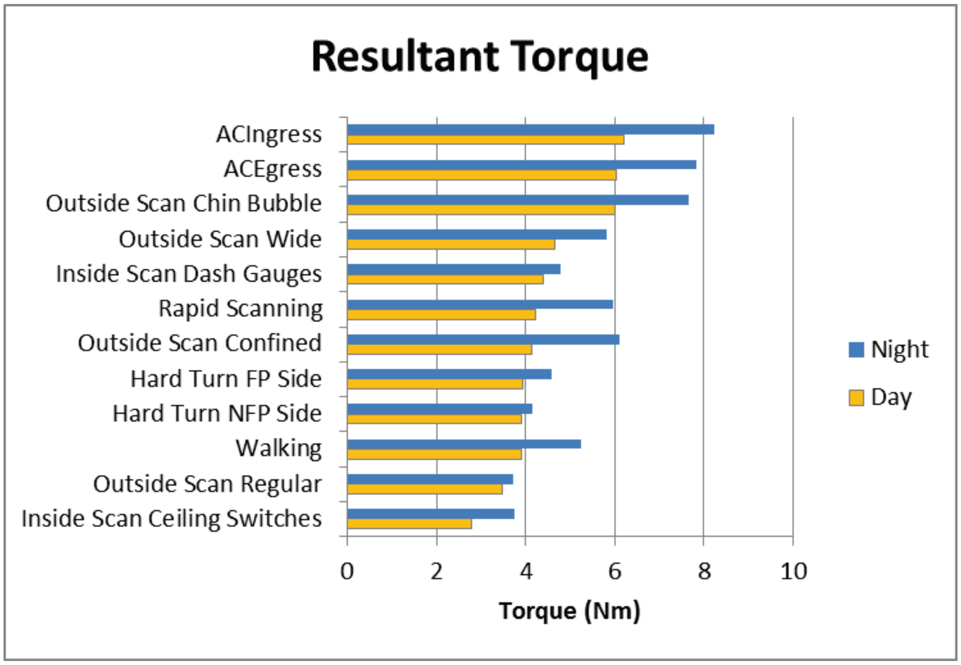

Figure 40: Flying Pilot Average Resultant Torquew

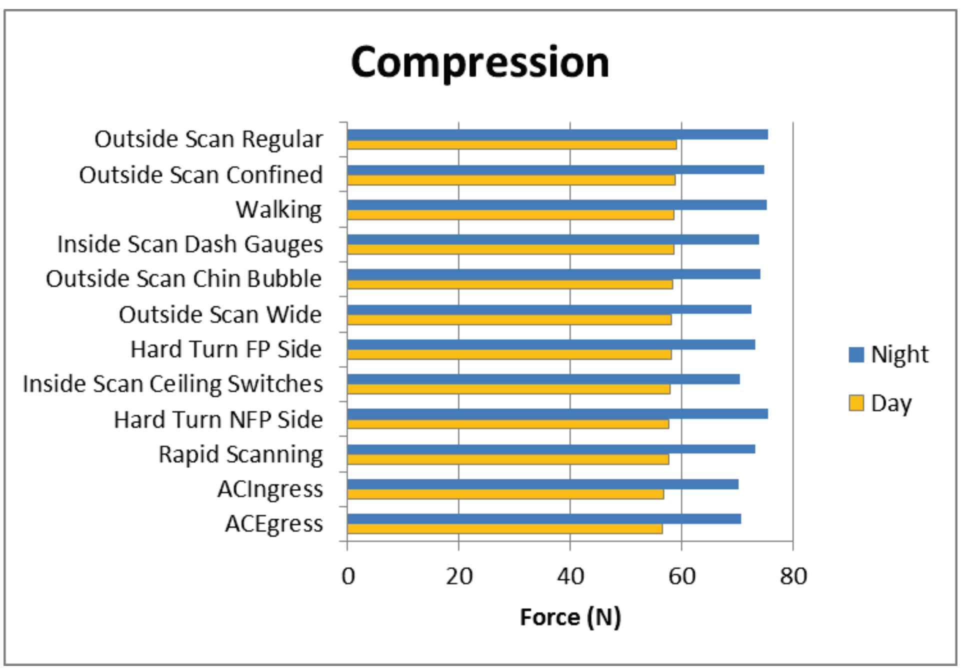

Figure 41: Flying Pilot Average Compression Force

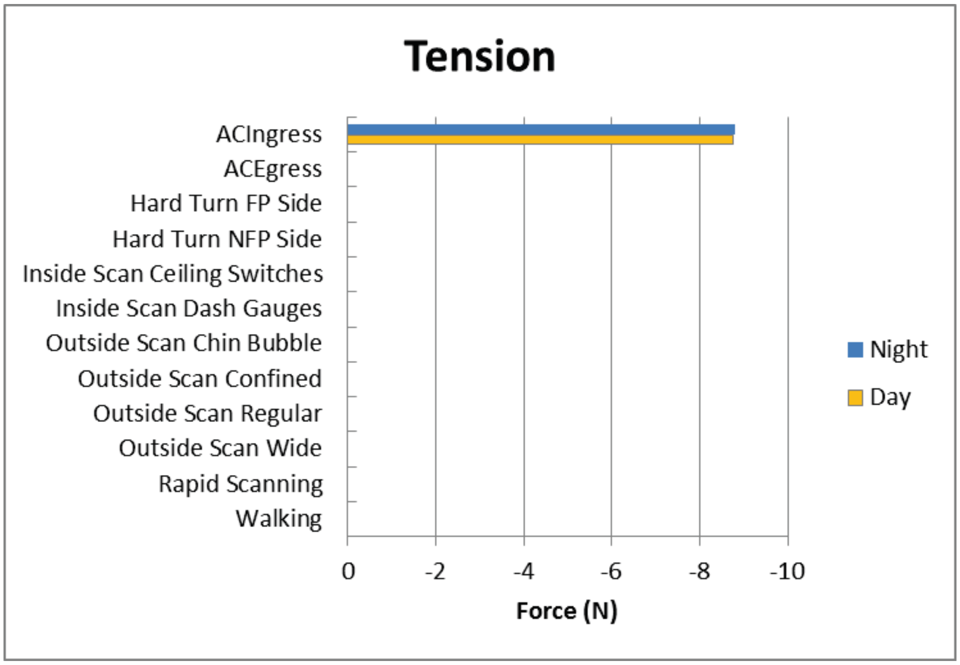

Figure 42: Flying Pilot Average Tension Force

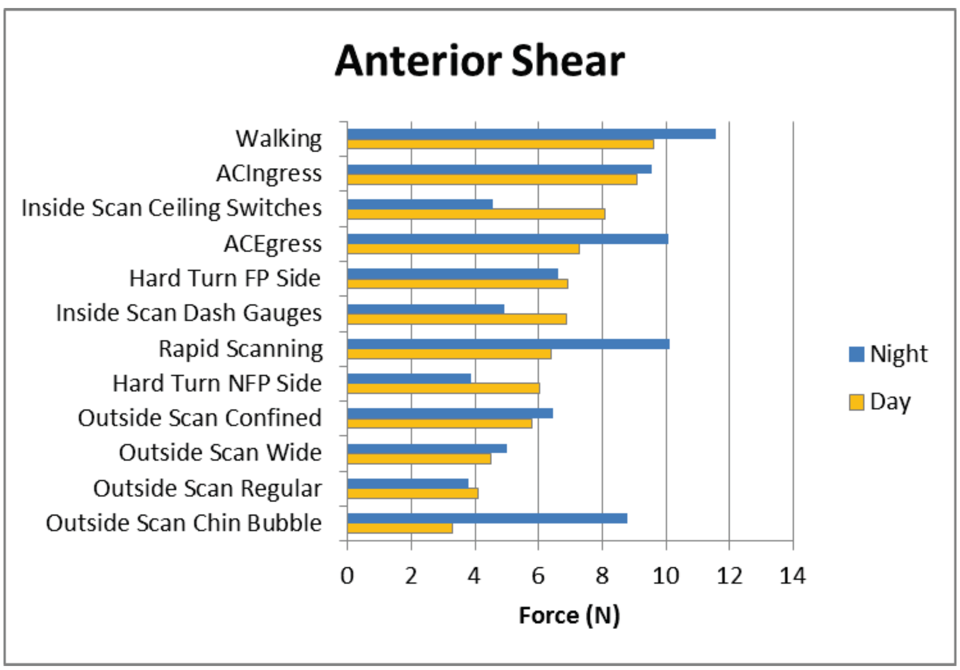

Figure 43: Flying Pilot Average Anterior Shear

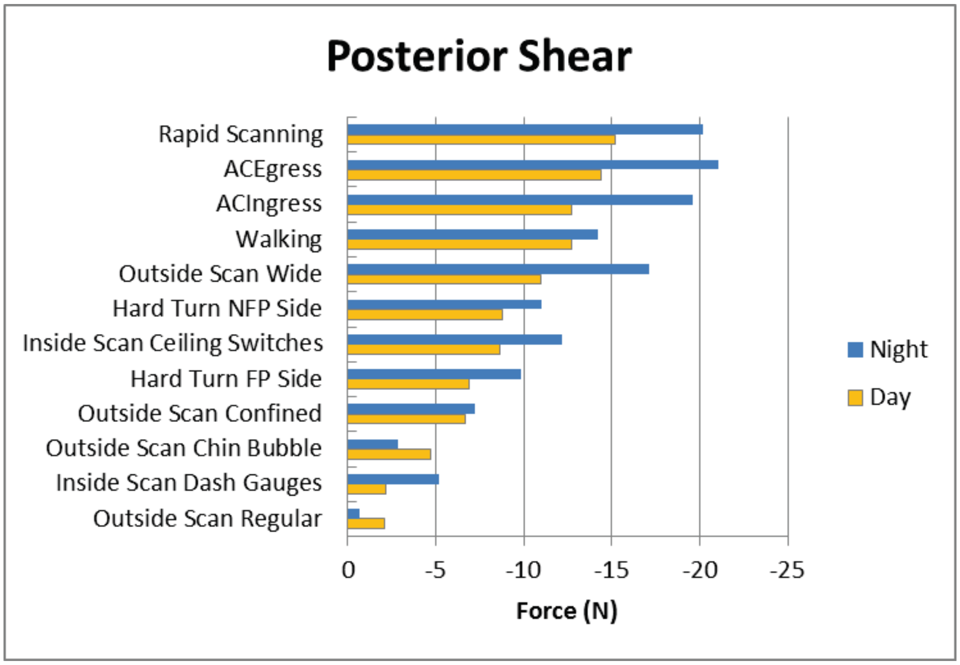

Figure 44: Flying Pilot Average Posterior Shear

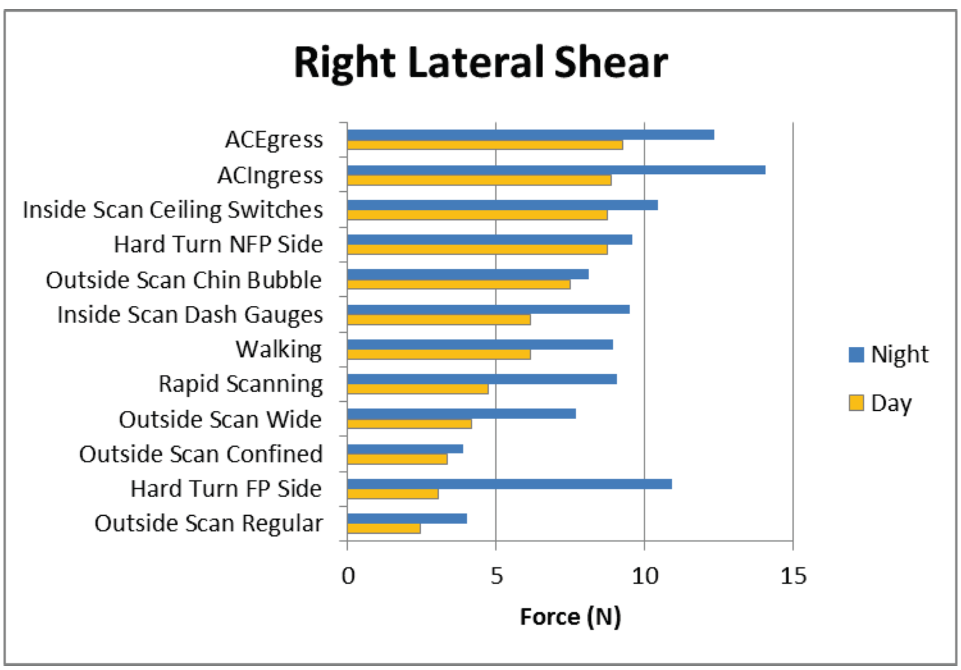

Figure 45: Flying Pilot Average Right Lateral Shear

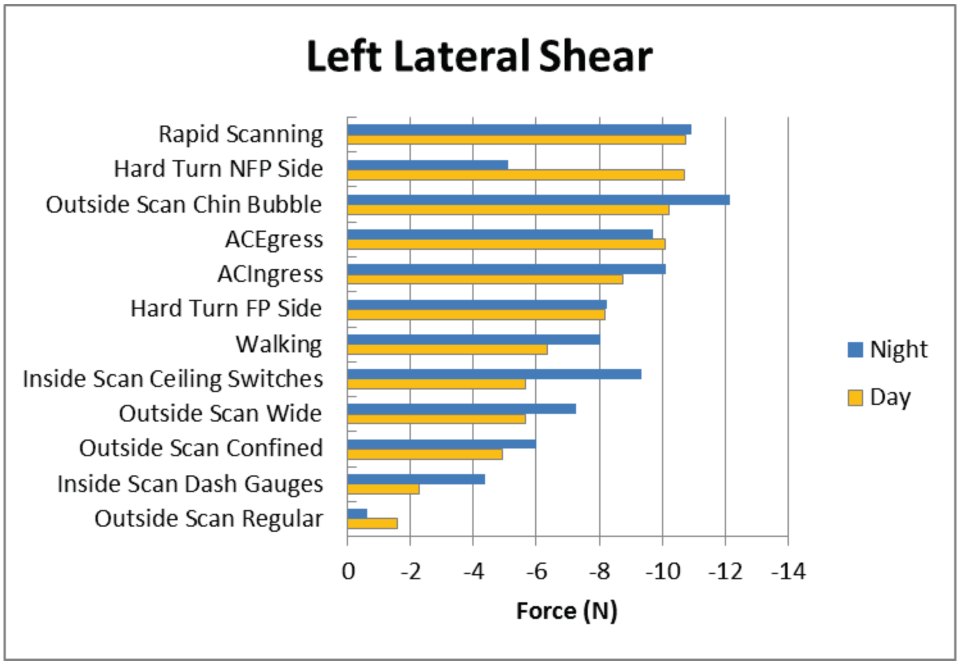

Figure 46: Flying Pilot Average Left Lateral Shear

Non-Flying Pilot

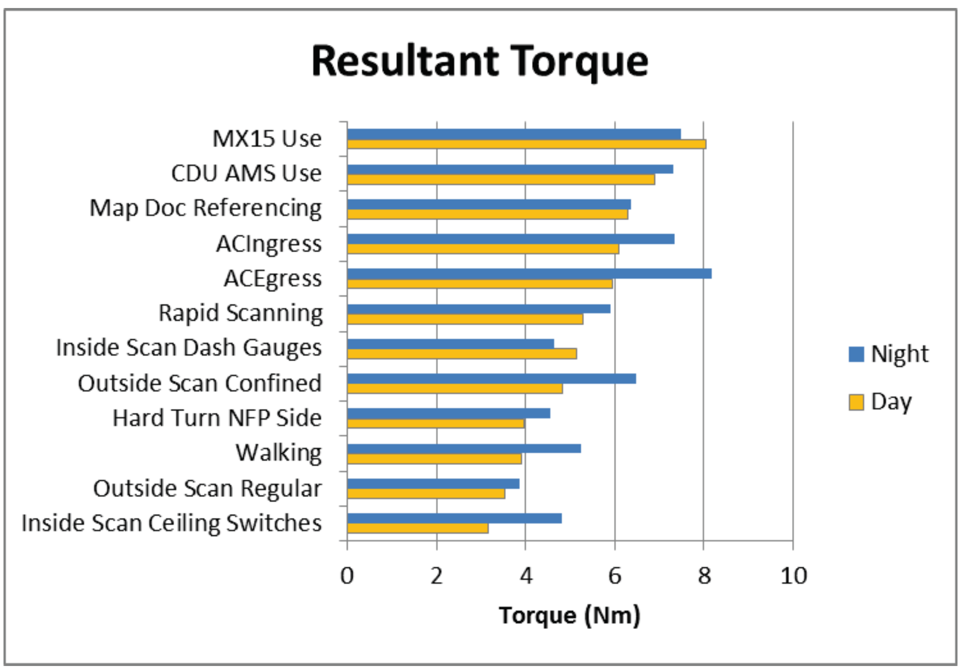

Figure 47: Non-Flying Pilot Average Resultant Torque

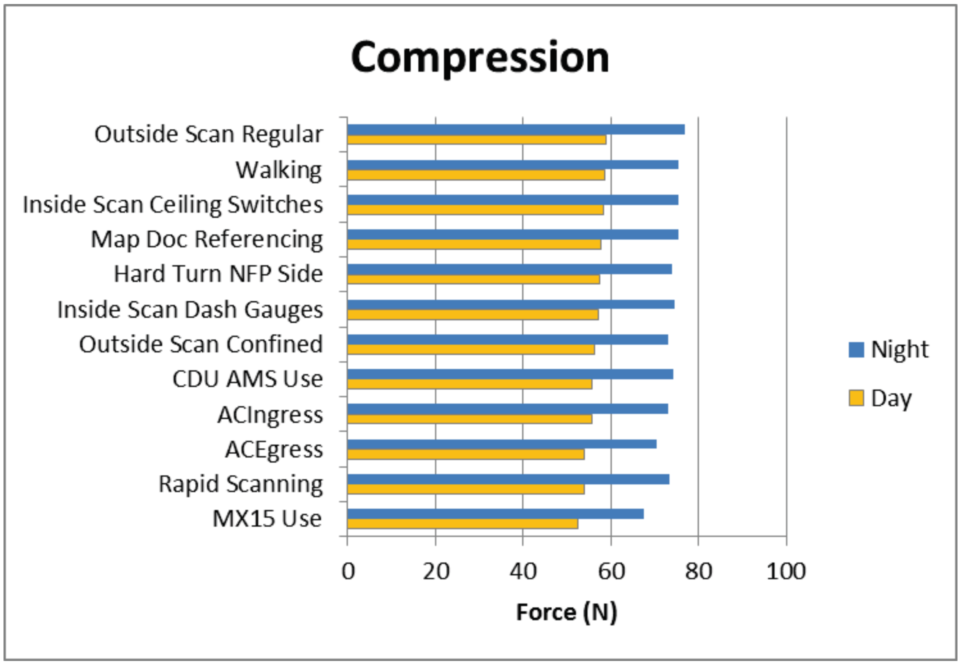

Figure 48: Non-Flying Pilot Average Compression Force

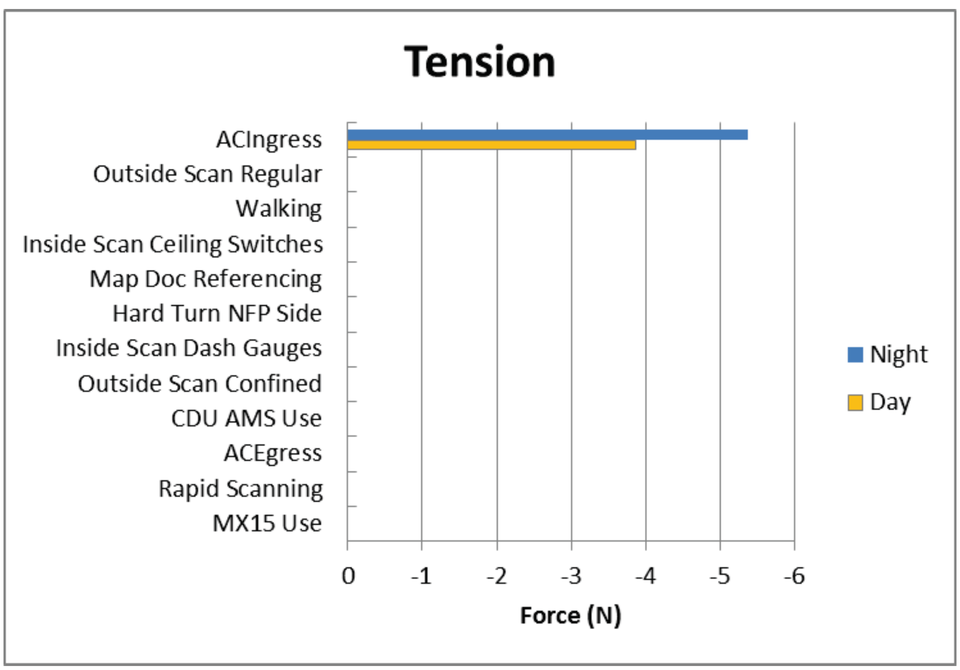

Figure 49: Non-Flying Pilot Average Tension Force

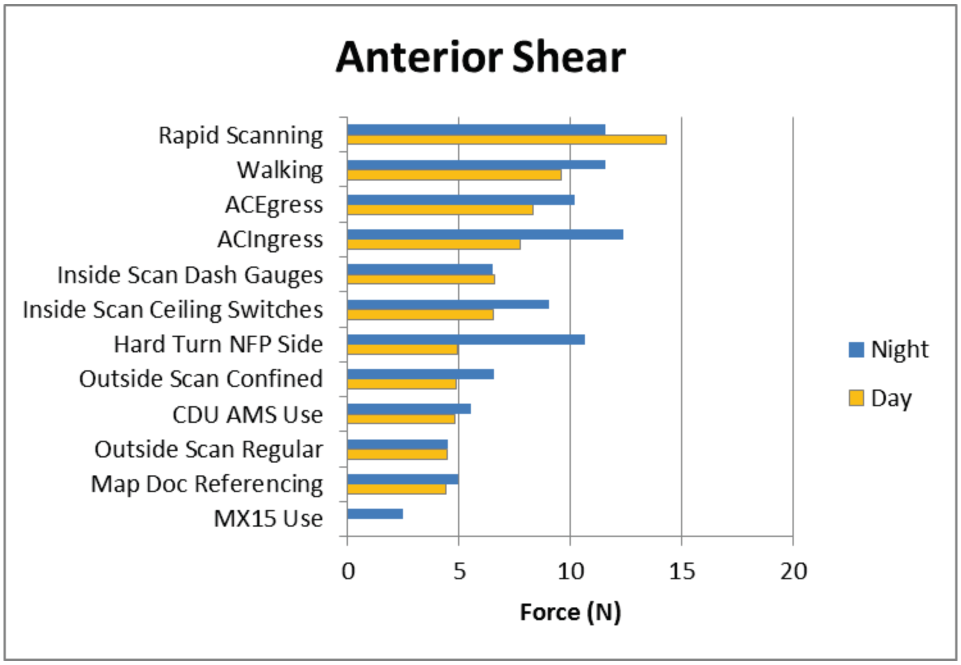

Figure 50: Non-Flying Pilot Average Anterior Shear

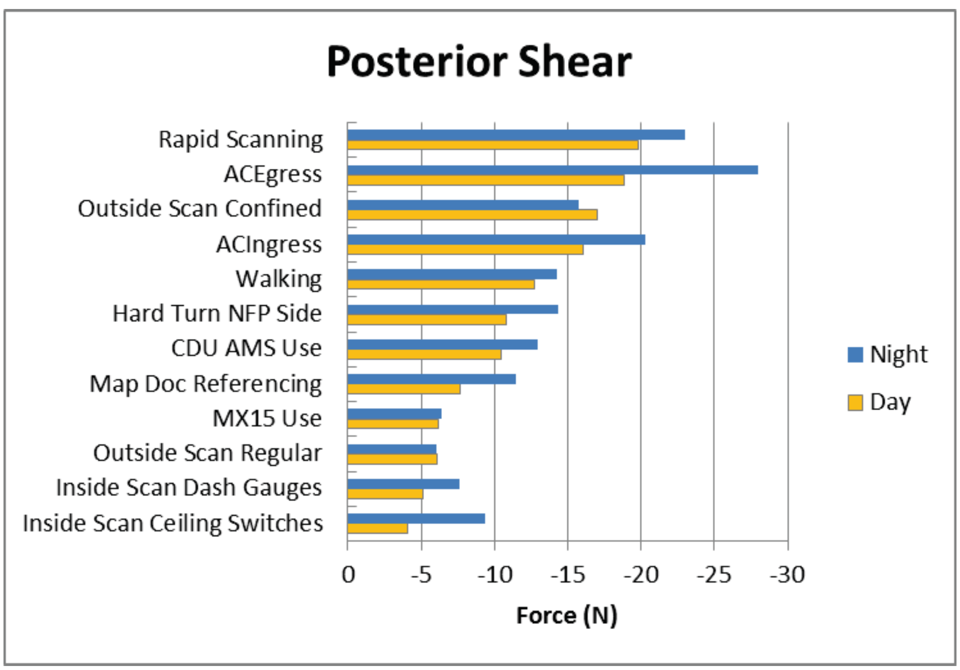

Figure 51: Non-Flying Pilot Average Posterior Shear

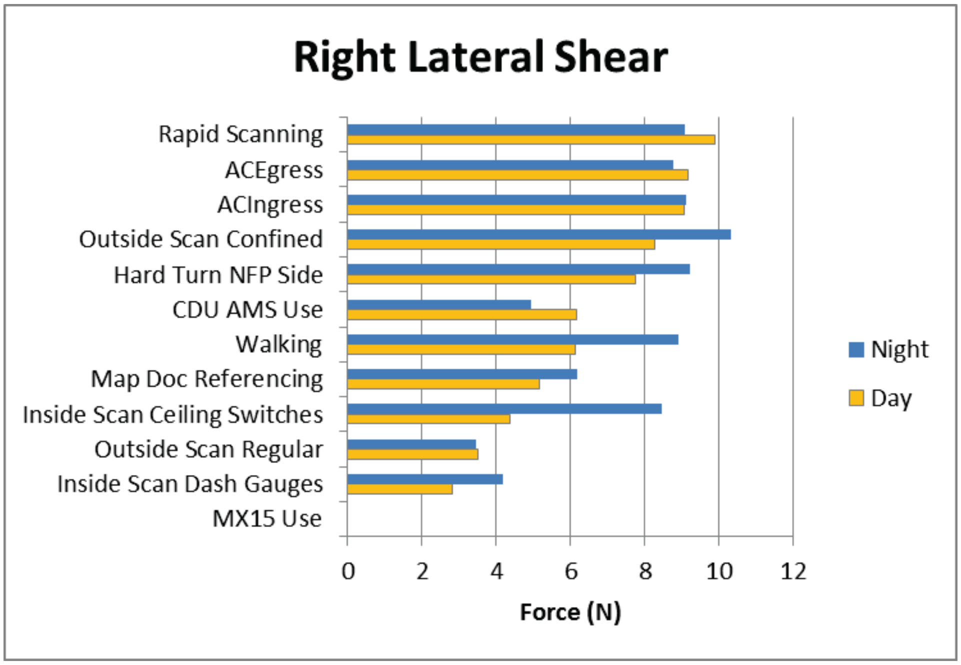

Figure 52: Non-Flying Pilot Average Right Lateral Shear

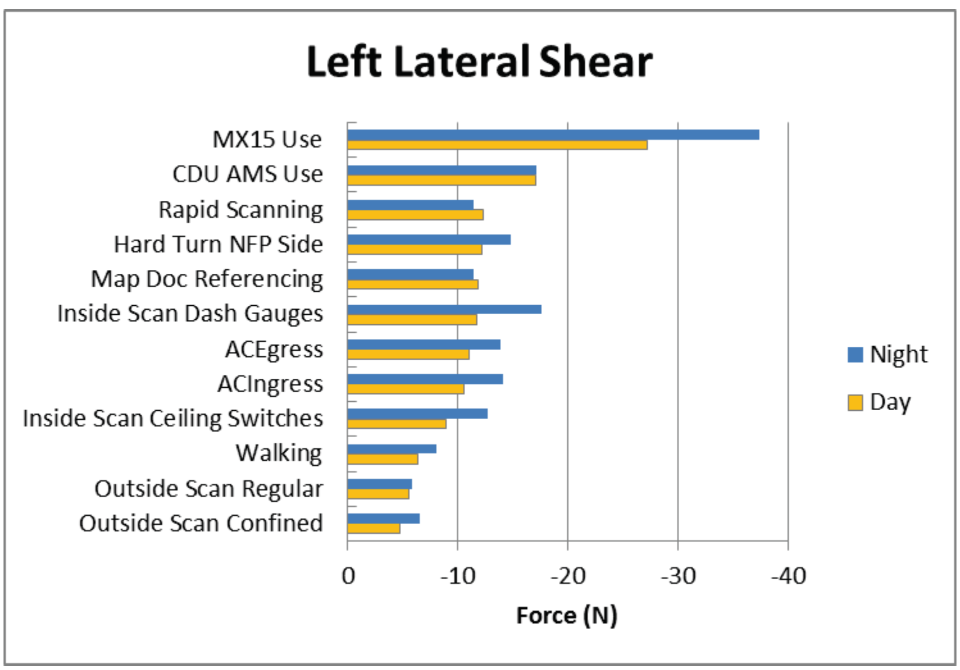

Figure 53: Non-Flying Pilot Average Left Lateral Shear

Annex C: Mission Task Sequences

Composite missions for the Logistic Support and Surveillance Mission (Vignette 1) and the Slung Load Training Mission (Vignette 2) are chronologically detailed in the following tables for the Flying Pilot (FP), Non-Flying Pilot (NFP), and Flight Engineer (FE).

For each task, timings for day and night are indicated, and the postural sequences required for each tasks are indicated, along with associated percentages of the task duration.

Vignette1: Logistics Support and Surveillance Mission

Flying Pilot:

Mission Clock	hr:min:sec	Segment	Task	Description	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %
0	0:00:00	**PRE-FLIGHT**	Load Mission Kit	from the hangar (if helmet)	600	900	Walking	100		
600	0:10:00		Open and Ingress AC		300	480	AC Ingress	100		
900	0:15:00		Start-up/Last Chance Insp.		600	600	Outside Scan Regular	25	Inside Scan Dash Gauges	75
1500	0:25:00		Post-start Checks		60	69	Outside Scan Regular	50	Inside Scan Dash Gauges	50
1560	0:26:00		Mission Kit Check (Hook)		120	120	Inside Scan Dash Gauges	100		
1680	0:28:00	**LOAD**	Troops		300	600	Outside Scan Regular	75	Inside Scan Dash Gauges	25
1980	0:33:00		Secure Troops/Equip in AC		60	60	Outside Scan Regular	50	Inside Scan Dash Gauges	50
2040	0:34:00	**TAXI**	Pre-taxi Checks	night adds wiggle checks	25	45	Outside Scan Regular	95	Inside Scan Dash Gauges	5
2065	0:34:25	**TAXI**	Taxi Field		60	60	Outside Scan Regular	85	Inside Scan Dash Gauges	15
2125	0:35:25	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5
2155	0:35:55		Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5
2175	0:36:15		Pre-departure Checks		60	60	Outside Scan Regular	95	Inside Scan Dash Gauges	5
2235	0:37:15		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
2250	0:37:30	**TRANSITION**	Transition to Forward Flt (Reg)		10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10
2260	0:37:40		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10
2270	0:37:50		Transition to Sect. Mov't Lead		240	240	Outside Scan Regular	90	Inside Scan Dash Gauges	10
2510	0:41:50		Non-tactical Climb		360	360	Outside Scan Regular	80	Inside Scan Dash Gauges	20
2870	0:47:50	**TRANSIT**	Transit Contour	example 20 min (incl 5 min nav)	900	900	Outside Scan Regular	95	Inside Scan Dash Gauges	5
3770	1:02:50		2-Full Check NFP Pilot		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
3785	1:03:05	**NAV/COMMS**	Enroute Navigation	Ongoing during transit	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5
4085	1:08:05	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10
4145	1:09:05		2-Full Check NFP Pilot		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
4160	1:09:20		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5
4280	1:11:20		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5
4310	1:11:50		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5
4320	1:12:00		Landing Tactical Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5
4330	1:12:10	**DROP-OFF**	Troops		120	120	Outside Scan Regular	85	Inside Scan Dash Gauges	15
4450	1:14:10	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5
4480	1:14:40		Take-off No Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5
4490	1:14:50	**TRANSITION**	Transition to Fwd Flt (Zoom)		40	40	Outside Scan Regular	90	Inside Scan Dash Gauges	10
4530	1:15:30		2-Full Check NFP Pilot		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
4545	1:15:45		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10
4555	1:15:55		Transition to Sect. Mov't Lead		240	240	Outside Scan Regular	90	Inside Scan Dash Gauges	10
4795	1:19:55		Zoom Climb	climb to 6000'	180	180	Outside Scan Regular	90	Inside Scan Dash Gauges	10
4975	1:22:55	**TRANSIT**	Transit Regular VFR	10 reg transit / 5 ISR Planning	600	600	Outside Scan Regular	95	Inside Scan Dash Gauges	5
5575	1:32:55	**RECCE**	Plan ISR		300	300	Outside Scan Regular	80	Inside Scan Dash Gauges	20
5875	1:37:55		Conduct ISR Profile	1.5 hr flights	5400	5400	Outside Scan Regular	80	Inside Scan Dash Gauges	20
11275	3:07:55	**RETASKING**	Receive New Tasking	Retrieve Slung load and rtn to base	600	600	Outside Scan Regular	99	Inside Scan Dash Gauges	1
11875	3:17:55		Conduct Detailed Planning	as part of enroute flight	300	300	Outside Scan Regular	90	Inside Scan Dash Gauges	10
12175	3:22:55		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
12190	3:23:10	**TRANSIT**	Transit Regular VFR	Transit to FARP (15 min) incl planning	600	600	Outside Scan Regular	95	Inside Scan Dash Gauges	5
12790	3:33:10		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
12805	3:33:25	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10
12865	3:34:25		2-Full Check NFP Pilot		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
12880	3:34:40		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5
13000	3:36:40		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5
13030	3:37:10		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5

Mission Clock	hr:min:sec	Segment	Task	Description	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %
13040	3:37:20		Landing Hover Confined		240	240	Outside Scan Confined	95	Inside Scan Dash Gauges	5
13280	3:41:20	**PICK-UP**	FARP Pick-up	fuel and supplies/plan next leg	750	750	Outside Scan Regular	95	Inside Scan Dash Gauges	5
14030	3:53:50		Post-start Checks		60	69	Outside Scan Regular	50	Inside Scan Dash Gauges	50
14090	3:54:50	**TAKE-OFF**	Pre-departure Checks		60	60	Outside Scan Regular	95	Inside Scan Dash Gauges	5
14150	3:55:50		Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5
14180	3:56:20		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
14195	3:56:35		Take-off Confined Area		30	30	Outside Scan Regular	85	Inside Scan Dash Gauges	15
14225	3:57:05	**TRANSITION**	Transition to Forward Flt (Reg)		10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10
14235	3:57:15		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10
14245	3:57:25		Transition to Sect. Mov't Lead		240	240	Outside Scan Regular	90	Inside Scan Dash Gauges	10
14485	4:01:25		Non-tactical Climb to Contour		60	60	Outside Scan Regular	80	Inside Scan Dash Gauges	20
14545	4:02:25	**TRANSIT**	Transit Contour	example 20 min	900	900	Outside Scan Regular	95	Inside Scan Dash Gauges	5
15445	4:17:25		2-Full Check NFP Pilot		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
15460	4:17:40	**NAV/COMMS**	Enroute Navigation	Ongoing during transit	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5
15760	4:22:40	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10
15820	4:23:40		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
15835	4:23:55		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5
15955	4:25:55		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5
15985	4:26:25		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5
15995	4:26:35		Landing Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5
16005	4:26:45		Landing Slide to Sling		20	20	Outside Scan Regular	100		
16025	4:27:05	**PICK-UP**	Hook up Slung Loads FE Manual		300	450	Outside Scan Regular	100		
16325	4:32:05	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5
16355	4:32:35		Take-off with Slung Load		60	60	Outside Scan Regular	100		
16415	4:33:35		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
16430	4:33:50		Control AC with Slung Load		15	15	Outside Scan Regular	100		
16445	4:34:05	**TRANSITION**	Transition to Fwd Flt (Slung Reg)		20	40	Outside Scan Regular	90	Inside Scan Dash Gauges	10
16465	4:34:25		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10
16475	4:34:35		Transition to Sect. Mov't Lead		240	240	Outside Scan Regular	90	Inside Scan Dash Gauges	10
16715	4:38:35		Non-tactical Climb		360	360	Outside Scan Regular	80	Inside Scan Dash Gauges	20
17075	4:44:35	**TRANSIT**	Transit with Slung Load		1800	1800	Outside Scan Regular	95	Inside Scan Dash Gauges	5
18875	5:14:35	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10
18935	5:15:35		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
18950	5:15:50		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5
19070	5:17:50		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5
19100	5:18:20		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5
19110	5:18:30	**DROP-OFF**	Slung Load Landing		300	450	Outside Scan Regular	99	Inside Scan Dash Gauges	1
19410	5:23:30		Slung Load Unhook Manual		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10
19470	5:24:30	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5
19500	5:25:00		Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5
19520	5:25:20		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5
19535	5:25:35	**TAXI**	Taxi Field		60	60	Outside Scan Regular	85	Inside Scan Dash Gauges	15
19595	5:26:35	**LAND**	Landing Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5
19605	5:26:45	**SHUTDOWN**	Post-landing Shutdown		240	240	Outside Scan Regular	10	Inside Scan Dash Gauges	90
19845	5:30:45		Close Cabin Door		10	10	Outside Scan Regular	10	Inside Scan Dash Gauges	90
19855	5:30:55		Egress AC		60	60	AC Egress	100		
19915	5:31:55									

Non-Flying Pilot and Flight Engineer:

Mission Clock	hr:min:sec	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3	FP Post 3 %
0	0:00:00					Walking	80	Equipment Handling Outside	20		
600	0:10:00					Door Opening Outside	100				
900	0:15:00	Map/Doc Referencing	50	CDU/AMS Use	30	Start-up/Last Chance Insp.	100				
1500	0:25:00	Map/Doc Referencing	50	CDU/AMS Use	30	Equipment Handling Inside	100				
1560	0:26:00					Sling Hook-up Manual	100				
1680	0:28:00	CDU/AMS Use	25	Map/Doc Referencing	25	Walking	95	Equipment Handling Outside	5		
1980	0:33:00	CDU/AMS Use	50			Equipment Handling Inside	100				
2040	0:34:00	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
2065	0:34:25	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
2125	0:35:25	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
2155	0:35:55	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
2175	0:36:15	Inside Scan Dash Gauges	50			Scan Troops on Sill	100				
2235	0:37:15	Inside Scan Dash Gauges	50			2-Full Check	100				
2250	0:37:30	Inside Scan Dash Gauges	40			Scan Regular Take-off	100				
2260	0:37:40	Inside Scan Dash Gauges	50			Door Closing Seated	100				
2270	0:37:50	Map/Doc Referencing	40	CDU/AMS Use	10	Scan Seated Door Closed	100				
2510	0:41:50	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
2870	0:47:50	Map/Doc Referencing	32	CDU/AMS Use	8	Transit Seated	75	Scan Seated Door Closed	25		
3770	1:02:50	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
3785	1:03:05	Map/Doc Referencing	35	CDU/AMS Use	15	Scan Seated Door Closed	100				
4085	1:08:05	Map/Doc Referencing	60			Scan Seated Door Closed	100				
4145	1:09:05	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
4160	1:09:20	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
4280	1:11:20	Inside Scan Dash Gauges	50			Scan Seated Door Closed	100				
4310	1:11:50	Inside Scan Dash Gauges	50			Door Opening Inside	100				
4320	1:12:00	Inside Scan Dash Gauges	30			Scan Troops on Sill	100				
4330	1:12:10	CDU/AMS Use	40	Inside Scan Dash Gauge	10	Equipment Handling Inside	50	Equipment Handling Outside	50		
4450	1:14:10	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
4480	1:14:40	Inside Scan Dash Gauges	30			Scan Regular Take-off	100				
4490	1:14:50	Inside Scan Dash Gauges	40			Scan Regular Take-off	100				
4530	1:15:30	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
4545	1:15:45	Inside Scan Dash Gauges	50			Door Closing Seated	100				
4555	1:15:55	Map/Doc Referencing	40	CDU/AMS Use	10	Scan Seated Door Closed	100				
4795	1:19:55	Inside Scan Dash Gauges	40			Scan Seated Door Closed	100				
4975	1:22:55	Inside Scan Dash Gauges	20			Transit Seated	75	Scan Seated Door Closed	25		
5575	1:32:55	Inside Scan Dash Gauges	40			Scan Seated Door Closed	100				
5875	1:37:55	MX-15 Use	75	CDU/AMS Use	10	Transit Seated	50	Scan Seated Door Closed	50		
11275	3:07:55	Map/Doc Referencing	40	CDU/AMS Use	30	Transit Seated	50	Scan Seated Door Closed	50		
11875	3:17:55	Map/Doc Referencing	40	CDU/AMS Use	30	Scan Seated Door Closed	50	Transit Seated	50		
12175	3:22:55	Inside Scan Dash Gauges	50			2-Full Check	100				
12190	3:23:10	Inside Scan Dash Gauges	20			Transit Seated	75	Scan Seated Door Closed	25		
12790	3:33:10	Inside Scan Dash Gauges	50			2-Full Check	100				
12805	3:33:25	Map/Doc Referencing	60			Scan Seated Door Closed	100				
12865	3:34:25	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
12880	3:34:40	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
13000	3:36:40	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
13030	3:37:10	Inside Scan Dash Gauges	50			Door Opening Inside	100				

Mission Clock	hr:min:sec	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3	FP Post 3 %
13040	3:37:20	Inside Scan Dash Gauges	20			Scan Confined	100				
13280	3:41:20	Inside Scan Dash Gauges	5			Walking	50	Start-up/Last Chance Insp.	50		
14030	3:53:50	Map/Doc Referencing	50	CDU/AMS Use	30	Equipment Handling Inside	100				
14090	3:54:50	Inside Scan Dash Gauges	50			Scan Troops on Sill	100				
14150	3:55:50	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
14180	3:56:20	Inside Scan Dash Gauges	50			2-Full Check	100				
14195	3:56:35	Inside Scan Dash Gauges	25			Scan Confined	100				
14225	3:57:05	Inside Scan Dash Gauges	40			Scan Regular Take-off	100				
14235	3:57:15	Inside Scan Dash Gauges	50			Door Closing Seated	100				
14245	3:57:25	Map/Doc Referencing	40	CDU/AMS Use	10	Scan Seated Door Closed	100				
14485	4:01:25	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
14545	4:02:25	Map/Doc Referencing	32	CDU/AMS Use	8	Transit Seated	75	Scan Seated Door Closed	25		
15445	4:17:25	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
15460	4:17:40	Map/Doc Referencing	35	CDU/AMS Use	15	Scan Seated Door Closed	100				
15760	4:22:40	Map/Doc Referencing	60			Scan Seated Door Closed	100				
15820	4:23:40	Inside Scan Dash Gauges	50			2-Full Check	100				
15835	4:23:55	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
15955	4:25:55	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
15985	4:26:25	Inside Scan Dash Gauges	50			Door Opening Inside	100				
15995	4:26:35	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
16005	4:26:45	Inside Scan Dash Gauges	10			Scan during Slide to Sling	100				
16025	4:27:05	Inside Scan Dash Gauges	10			Walking	50	Sling Hook-up Manual	50		
16325	4:32:05	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
16355	4:32:35	Inside Scan Dash Gauges	50			Scan Slung Load	100				
16415	4:33:35	Inside Scan Dash Gauges	50			2-Full Check	100				
16430	4:33:50	Inside Scan Dash Gauges	90			Scan Slung Load	100				
16445	4:34:05	Inside Scan Dash Gauges	40			Scan Slung Load	100				
16465	4:34:25	Inside Scan Dash Gauges	50			Door Closing Seated	100				
16475	4:34:35	Map/Doc Referencing	40	CDU/AMS Use	10	Scan Seated Door Closed	100				
16715	4:38:35	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
17075	4:44:35	Inside Scan Dash Gauges	50			Scan Slung Load	20	Scan Regular Landing	80		
18875	5:14:35	Map/Doc Referencing	60			Scan Seated Door Closed	100				
18935	5:15:35	Inside Scan Dash Gauges	50			2-Full Check	100				
18950	5:15:50	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
19070	5:17:50	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
19100	5:18:20	Inside Scan Dash Gauges	50			Door Opening Inside	100				
19110	5:18:30	Inside Scan Dash Gauges	10			Scan Slung Load	100				
19410	5:23:30	Inside Scan Dash Gauges	50			Sling Unhook Manual	100				
19470	5:24:30	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
19500	5:25:00	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
19520	5:25:20	Inside Scan Dash Gauges	50			2-Full Check	100				
19535	5:25:35	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
19595	5:26:35	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
19605	5:26:45	Inside Scan Dash Gauges	90			Equipment Handling Inside	70	Scan Regular Landing	10	2-Full Check	20
19845	5:30:45	Inside Scan Dash Gauges	90			Door Closing Outside	100				
19855	5:30:55					Walking	100				
19915	5:31:55										

Vignette 2: Slung Load Training Mission

Flying Pilot (FP):

Mission Clock	hr:min:sec	Segment	Task	Description	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %	NFP Post 1	NFP Post 1 %
0	0:00:00	**PRE-FLIGHT**	Load Mission Kit	from the hangar (if helmet)	600	900	Walking	100			Walking	100
600	0:10:00		Open and Ingress AC		300	480	AC Ingress	100			AC Ingress	100
900	0:15:00		Start-up/Last Chance Insp.		600	600	Outside Scan Regular	25	Inside Scan Dash Gauges	75	Outside Scan Regular	20
1500	0:25:00		Post-start Checks		60	69	Outside Scan Regular	50	Inside Scan Dash Gauges	50	Outside Scan Regular	20
1560	0:26:00		Mission Kit Check (Hook)		120	120	Inside Scan Dash Gauges	100			Inside Scan Dash Gauge	100
1680	0:28:00	**TAXI**	Pre-taxi Checks	night adds wiggle checks	25	45	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Inside Scan Dash Gauge	50
1705	0:28:25	**TAXI**	Taxi Field		60	60	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Regular	50
1765	0:29:25	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
1795	0:29:55		Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
1815	0:30:15		Pre-departure Checks		60	60	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
1875	0:31:15		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
1890	0:31:30	**TRANSITION**	Transition to Forward Flt (Reg)		10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
1900	0:31:40		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
1910	0:31:50	**TRANSIT**	Transit Regular VFR	Transit to pickup (5 min)	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
2210	0:36:50	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	40
2270	0:37:50		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
2285	0:38:05		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
2405	0:40:05		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
2435	0:40:35		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
2445	0:40:45		Landing Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
2455	0:40:55		Landing Slide to Sling		20	20	Outside Scan Regular	100			Outside Scan Regular	90
2475	0:41:15	**PICK-UP**	Hook up Slung Loads FE Manual		300	450	Outside Scan Regular	100			Outside Scan Regular	90
2775	0:46:15	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
2805	0:46:45		Take-off with Slung Load		60	60	Outside Scan Regular	100			Outside Scan Regular	50
2865	0:47:45		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
2880	0:48:00		Control AC with Slung Load		15	15	Outside Scan Regular	100			Outside Scan Regular	10
2895	0:48:15	**TRANSITION**	Transition to Fwd Flt (Slung Reg)		20	40	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
2915	0:48:35		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
2925	0:48:45		Non-tactical Climb		180	180	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
3105	0:51:45	**TRANSIT**	Transit with Slung Load	Transit to drop-off (5 min)	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
3405	0:56:45	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	40
3465	0:57:45		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
3480	0:58:00		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
3600	1:00:00		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
3630	1:00:30		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
3640	1:00:40	**DROP-OFF**	Slung Load Landing		300	450	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	90
3940	1:05:40		Slung Load Unhook Manual		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
4000	1:06:40	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
4030	1:07:10		Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
4050	1:07:30		Pre-departure Checks		60	60	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
4110	1:08:30		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
4125	1:08:45	**TRANSITION**	Transition to Forward Flt (Reg)		10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
4135	1:08:55		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
4145	1:09:05	**TRANSIT**	Transit Regular VFR	Transit to pickup (5 min)	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
4445	1:14:05	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	40
4505	1:15:05		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
4520	1:15:20		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80

Mission Clock	hr:min:sec	Segment	Task	Description	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %	NFP Post 1	NFP Post 1 %
4640	1:17:20		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
4670	1:17:50		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
4680	1:18:00		Landing Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
4690	1:18:10		Landing Slide to Sling		20	20	Outside Scan Regular	100			Outside Scan Regular	90
4710	1:18:30	**PICK-UP**	Hook up Slung Loads FE Manual		300	450	Outside Scan Regular	100			Outside Scan Regular	90
5010	1:23:30	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
5040	1:24:00		Take-off with Slung Load		60	60	Outside Scan Regular	100			Outside Scan Regular	50
5100	1:25:00		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
5115	1:25:15		Control AC with Slung Load		15	15	Outside Scan Regular	100			Outside Scan Regular	10
5130	1:25:30	**TRANSITION**	Transition to Fwd Flt (Slung Reg)		20	40	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
5150	1:25:50		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
5160	1:26:00		Non-tactical Climb		180	180	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
5340	1:29:00	**TRANSIT**	Transit with Slung Load	Transit to drop-off (5 min)	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
5640	1:34:00	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	40
5700	1:35:00		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
5715	1:35:15		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
5835	1:37:15		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
5865	1:37:45		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
5875	1:37:55	**DROP-OFF**	Slung Load Landing		300	450	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	90
6175	1:42:55		Slung Load Unhook Manual		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
6235	1:43:55	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
6265	1:44:25		Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
6285	1:44:45		Pre-departure Checks		60	60	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
6345	1:45:45		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
6360	1:46:00	**TRANSITION**	Transition to Forward Flt (Reg)		10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
6370	1:46:10		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
6380	1:46:20	**TRANSIT**	Transit Regular VFR	Transit to pickup (5 min)	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
6680	1:51:20	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	40
6740	1:52:20		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
6755	1:52:35		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
6875	1:54:35		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
6905	1:55:05		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
6915	1:55:15		Landing Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
6925	1:55:25		Landing Slide to Sling		20	20	Outside Scan Regular	100			Outside Scan Regular	90
6945	1:55:45	**PICK-UP**	Hook up Slung Loads FE Manual		300	450	Outside Scan Regular	100			Outside Scan Regular	90
7245	2:00:45	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
7275	2:01:15		Take-off with Slung Load		60	60	Outside Scan Regular	100			Outside Scan Regular	50
7335	2:02:15		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
7350	2:02:30		Control AC with Slung Load		15	15	Outside Scan Regular	100			Outside Scan Regular	10
7365	2:02:45	**TRANSITION**	Transition to Fwd Flt (Slung Reg)		20	40	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	60
7385	2:03:05		Close Cabin Door	at 80 knts	10	10	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
7395	2:03:15		Non-tactical Climb		180	180	Outside Scan Regular	80	Inside Scan Dash Gauges	20	Outside Scan Regular	70
7575	2:06:15	**TRANSIT**	Transit with Slung Load	Transit to drop-off (5 min)	300	300	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
7875	2:11:15	**LAND**	Review Terminal Navigation		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	40
7935	2:12:15		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
7950	2:12:30		Conduct Terminal Navigation		120	120	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	80
8070	2:14:30		Final Approach		30	30	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50

Mission Clock	hr:min:sec	Segment	Task	Description	Duration (sec)	Dur. Night (sec)	FP Post 1	FP Post 1 %	FP Post 2	FP Post 2 %	NFP Post 1	NFP Post 1 %
8100	2:15:00		Cabin Door Opening	once AC slows below 80 knts	10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
8110	2:15:10	**DROP-OFF**	Slung Load Landing		300	450	Outside Scan Regular	99	Inside Scan Dash Gauges	1	Outside Scan Regular	90
8410	2:20:10		Slung Load Unhook Manual		60	60	Outside Scan Regular	90	Inside Scan Dash Gauges	10	Outside Scan Regular	50
8470	2:21:10	**TAKE-OFF**	Pre-Takeoff Checks		30	45	Inside Scan Dash Gauges	95	Outside Scan Regular	5	Outside Scan Regular	50
8500	2:21:40		Take-off to Hover Regular		20	20	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
8520	2:22:00		2-Full Check FE		15	15	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
8535	2:22:15	**TAXI**	Taxi Field		60	60	Outside Scan Regular	85	Inside Scan Dash Gauges	15	Outside Scan Regular	50
8595	2:23:15	**LAND**	Landing Hover Regular		10	10	Outside Scan Regular	95	Inside Scan Dash Gauges	5	Outside Scan Regular	50
8605	2:23:25	**SHUTDOWN**	Post-landing Shutdown		240	240	Outside Scan Regular	10	Inside Scan Dash Gauges	90	Outside Scan Regular	10
8845	2:27:25		Close Cabin Door		10	10	Outside Scan Regular	10	Inside Scan Dash Gauges	90	Outside Scan Regular	10
8855	2:27:35		Egress AC		60	60	AC Egress	100			AC Egress	100
8915	2:28:35											

Non-Flying Pilot (NFP) and Flight Engineer (FE):

Mission Clock	hr:min:sec	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3	FP Post 3 %
0	0:00:00					Walking	80	Equipment Handling Outside	20		
600	0:10:00					Door Opening Outside	100				
900	0:15:00	Map/Doc Referencing	50	CDU/AMS Use	30	Start-up/Last Chance Insp.	100				
1500	0:25:00	Map/Doc Referencing	50	CDU/AMS Use	30	Equipment Handling Inside	100				
1560	0:26:00					Sling Hook-up Manual	100				
1680	0:28:00	Inside Scan Ceiling Switch	25	CDU/AMS Use	25	Scan Seated Door Closed	100				
1705	0:28:25	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
1765	0:29:25	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
1795	0:29:55	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
1815	0:30:15	Inside Scan Dash Gauges	50			Scan Troops on Sill	100				
1875	0:31:15	Inside Scan Dash Gauges	50			2-Full Check	100				
1890	0:31:30	Inside Scan Dash Gauges	40			Scan Regular Take-off	100				
1900	0:31:40	Inside Scan Dash Gauges	50			Door Closing Seated	100				
1910	0:31:50	Inside Scan Dash Gauges	20			Transit Seated	75	Scan Seated Door Closed	25		
2210	0:36:50	Map/Doc Referencing	60			Scan Seated Door Closed	100				
2270	0:37:50	Inside Scan Dash Gauges	50			2-Full Check	100				
2285	0:38:05	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
2405	0:40:05	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
2435	0:40:35	Inside Scan Dash Gauges	50			Door Opening Inside	100				
2445	0:40:45	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
2455	0:40:55	Inside Scan Dash Gauges	10			Scan during Slide to Sling	100				
2475	0:41:15	Inside Scan Dash Gauges	10			Walking	50	Sling Hook-up Manual	50		
2775	0:46:15	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
2805	0:46:45	Inside Scan Dash Gauges	50			Scan Slung Load	100				
2865	0:47:45	Inside Scan Dash Gauges	50			2-Full Check	100				
2880	0:48:00	Inside Scan Dash Gauges	90			Scan Slung Load	100				
2895	0:48:15	Inside Scan Dash Gauges	40			Scan Slung Load	100				
2915	0:48:35	Inside Scan Dash Gauges	50			Door Closing Seated	100				
2925	0:48:45	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
3105	0:51:45	Inside Scan Dash Gauges	50			Scan Slung Load	20	Scan Regular Landing	80		
3405	0:56:45	Map/Doc Referencing	60			Scan Seated Door Closed	100				
3465	0:57:45	Inside Scan Dash Gauges	50			2-Full Check	100				
3480	0:58:00	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
3600	1:00:00	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
3630	1:00:30	Inside Scan Dash Gauges	50			Door Opening Inside	100				
3640	1:00:40	Inside Scan Dash Gauges	10			Scan Slung Load	100				
3940	1:05:40	Inside Scan Dash Gauges	50			Sling Unhook Manual	100				
4000	1:06:40	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
4030	1:07:10	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
4050	1:07:30	Inside Scan Dash Gauges	50			Scan Troops on Sill	100				
4110	1:08:30	Inside Scan Dash Gauges	50			2-Full Check	100				
4125	1:08:45	Inside Scan Dash Gauges	40			Scan Regular Take-off	100				
4135	1:08:55	Inside Scan Dash Gauges	50			Door Closing Seated	100				
4145	1:09:05	Inside Scan Dash Gauges	20			Transit Seated	75	Scan Seated Door Closed	25		
4445	1:14:05	Map/Doc Referencing	60			Scan Seated Door Closed	100				
4505	1:15:05	Inside Scan Dash Gauges	50			2-Full Check	100				
4520	1:15:20	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				

Mission Clock	hr:min:sec	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3	FP Post 3 %
4640	1:17:20	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
4670	1:17:50	Inside Scan Dash Gauges	50			Door Opening Inside	100				
4680	1:18:00	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
4690	1:18:10	Inside Scan Dash Gauges	10			Scan during Slide to Sling	100				
4710	1:18:30	Inside Scan Dash Gauges	10			Walking	50	Sling Hook-up Manual	50		
5010	1:23:30	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
5040	1:24:00	Inside Scan Dash Gauges	50			Scan Slung Load	100				
5100	1:25:00	Inside Scan Dash Gauges	50			2-Full Check	100				
5115	1:25:15	Inside Scan Dash Gauges	90			Scan Slung Load	100				
5130	1:25:30	Inside Scan Dash Gauges	40			Scan Slung Load	100				
5150	1:25:50	Inside Scan Dash Gauges	50			Door Closing Seated	100				
5160	1:26:00	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
5340	1:29:00	Inside Scan Dash Gauges	50			Scan Slung Load	20	Scan Regular Landing	80		
5640	1:34:00	Map/Doc Referencing	60			Scan Seated Door Closed	100				
5700	1:35:00	Inside Scan Dash Gauges	50			2-Full Check	100				
5715	1:35:15	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
5835	1:37:15	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
5865	1:37:45	Inside Scan Dash Gauges	50			Door Opening Inside	100				
5875	1:37:55	Inside Scan Dash Gauges	10			Scan Slung Load	100				
6175	1:42:55	Inside Scan Dash Gauges	50			Sling Unhook Manual	100				
6235	1:43:55	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
6265	1:44:25	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
6285	1:44:45	Inside Scan Dash Gauges	50			Scan Troops on Sill	100				
6345	1:45:45	Inside Scan Dash Gauges	50			2-Full Check	100				
6360	1:46:00	Inside Scan Dash Gauges	40			Scan Regular Take-off	100				
6370	1:46:10	Inside Scan Dash Gauges	50			Door Closing Seated	100				
6380	1:46:20	Inside Scan Dash Gauges	20			Transit Seated	75	Scan Seated Door Closed	25		
6680	1:51:20	Map/Doc Referencing	60			Scan Seated Door Closed	100				
6740	1:52:20	Inside Scan Dash Gauges	50			2-Full Check	100				
6755	1:52:35	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
6875	1:54:35	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		
6905	1:55:05	Inside Scan Dash Gauges	50			Door Opening Inside	100				
6915	1:55:15	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
6925	1:55:25	Inside Scan Dash Gauges	10			Scan during Slide to Sling	100				
6945	1:55:45	Inside Scan Dash Gauges	10			Walking	50	Sling Hook-up Manual	50		
7245	2:00:45	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
7275	2:01:15	Inside Scan Dash Gauges	50			Scan Slung Load	100				
7335	2:02:15	Inside Scan Dash Gauges	50			2-Full Check	100				
7350	2:02:30	Inside Scan Dash Gauges	90			Scan Slung Load	100				
7365	2:02:45	Inside Scan Dash Gauges	40			Scan Slung Load	100				
7385	2:03:05	Inside Scan Dash Gauges	50			Door Closing Seated	100				
7395	2:03:15	Inside Scan Dash Gauges	30			Scan Seated Door Closed	100				
7575	2:06:15	Inside Scan Dash Gauges	50			Scan Slung Load	20	Scan Regular Landing	80		
7875	2:11:15	Map/Doc Referencing	60			Scan Seated Door Closed	100				
7935	2:12:15	Inside Scan Dash Gauges	50			2-Full Check	100				
7950	2:12:30	Map/Doc Referencing	15	Inside Scan Dash Gauge	5	Scan Seated Door Closed	100				
8070	2:14:30	Inside Scan Dash Gauges	50			Door Opening Inside	25	Scan Regular Landing	75		

Mission Clock	hr:min:sec	NFP Post 2	NFP Post 2 %	NFP Post 3	NFP Post 3 %	FE Post 1	FE Post 1 %	FE Post 2	FE Post 2 %	FE Post 3	FP Post 3 %
8100	2:15:00	Inside Scan Dash Gauges	50			Door Opening Inside	100				
8110	2:15:10	Inside Scan Dash Gauges	10			Scan Slung Load	100				
8410	2:20:10	Inside Scan Dash Gauges	50			Sling Unhook Manual	100				
8470	2:21:10	Inside Scan Dash Gauges	25	CDU/AMS Use	25	Equipment Handling Inside	100				
8500	2:21:40	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
8520	2:22:00	Inside Scan Dash Gauges	50			2-Full Check	100				
8535	2:22:15	Inside Scan Dash Gauges	50			Scan Regular Take-off	100				
8595	2:23:15	Inside Scan Dash Gauges	50			Scan Regular Landing	100				
8605	2:23:25	Inside Scan Dash Gauges	90			Equipment Handling Inside	70	Scan Regular Landing	10	2-Full Check	20
8845	2:27:25	Inside Scan Dash Gauges	90			Door Closing Outside	100				
8855	2:27:35					Walking	100				
8915	2:28:35										

Annex D: Summary Cumulative Mission Results – Resultant Torque

Vignette 1 – Logistics Support and Surveillance Mission

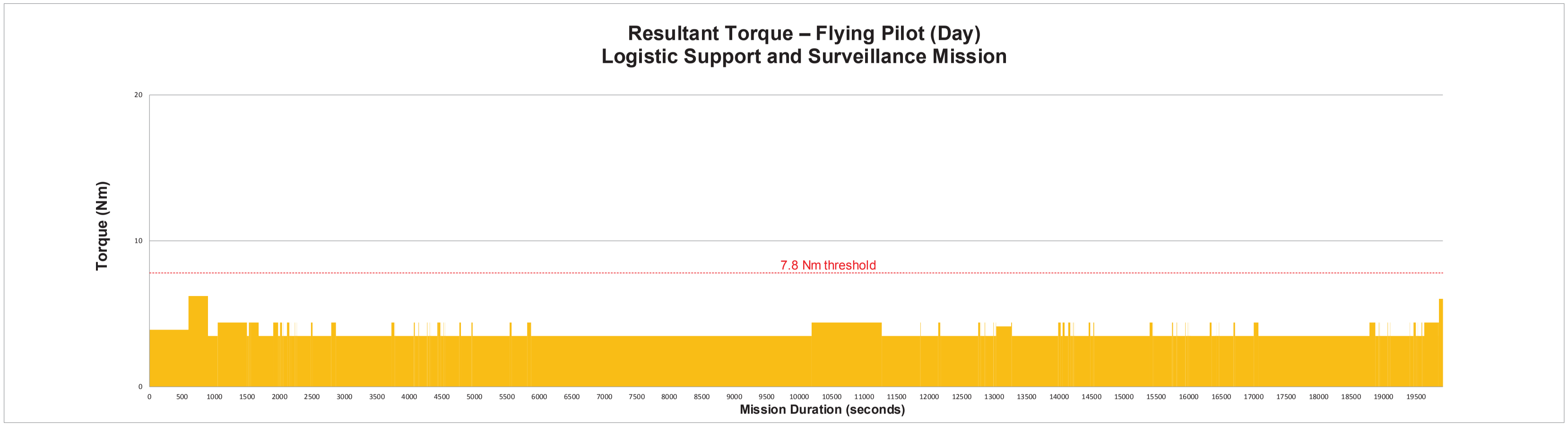

Figure 54: Logistic Support and Surveillance Mission – Flying Pilot (Day) Resultant Torque

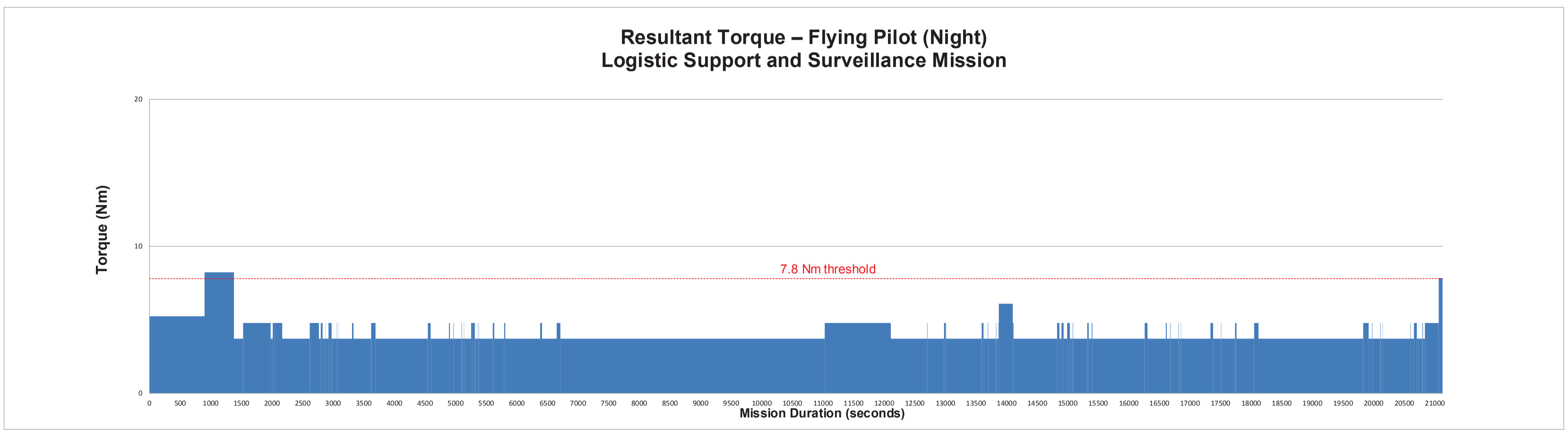

Figure 55: Logistic Support and Surveillance Mission – Flying Pilot (Night) Resultant Torque

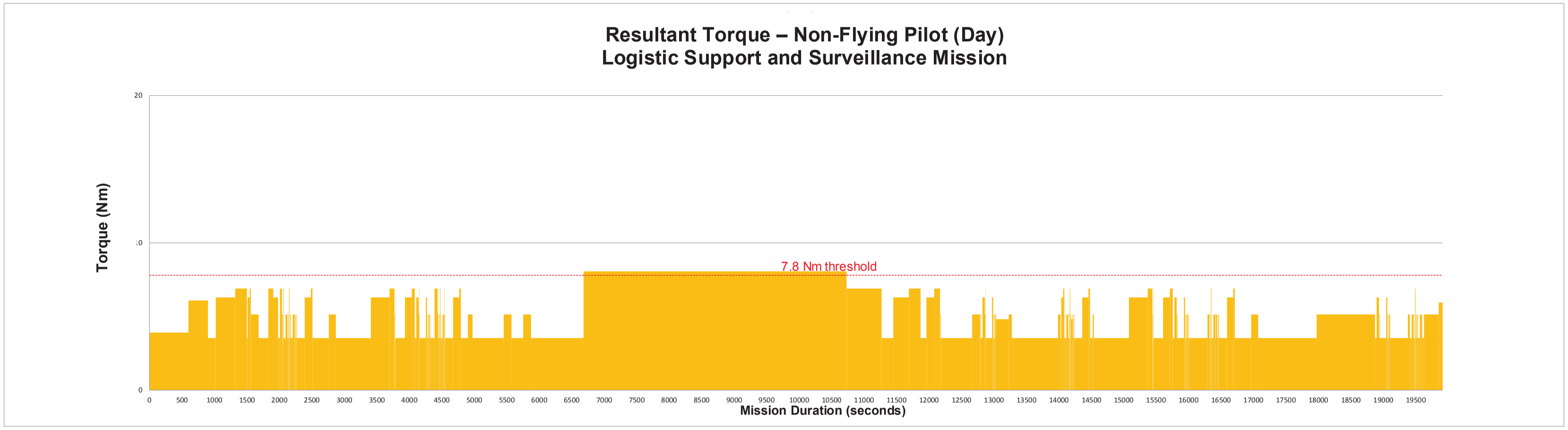

Figure 56: Logistic Support and Surveillance Mission – Non-Flying Pilot (Day) Resultant Torque

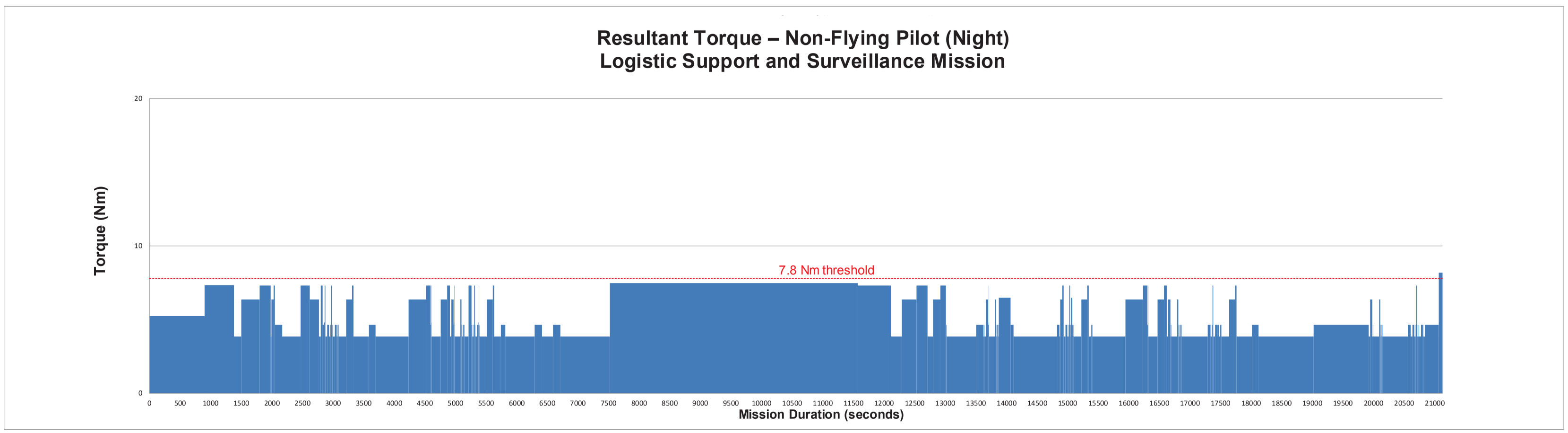

Figure 57: Logistic Support and Surveillance Mission – Non-Flying Pilot (Night) Resultant Torque

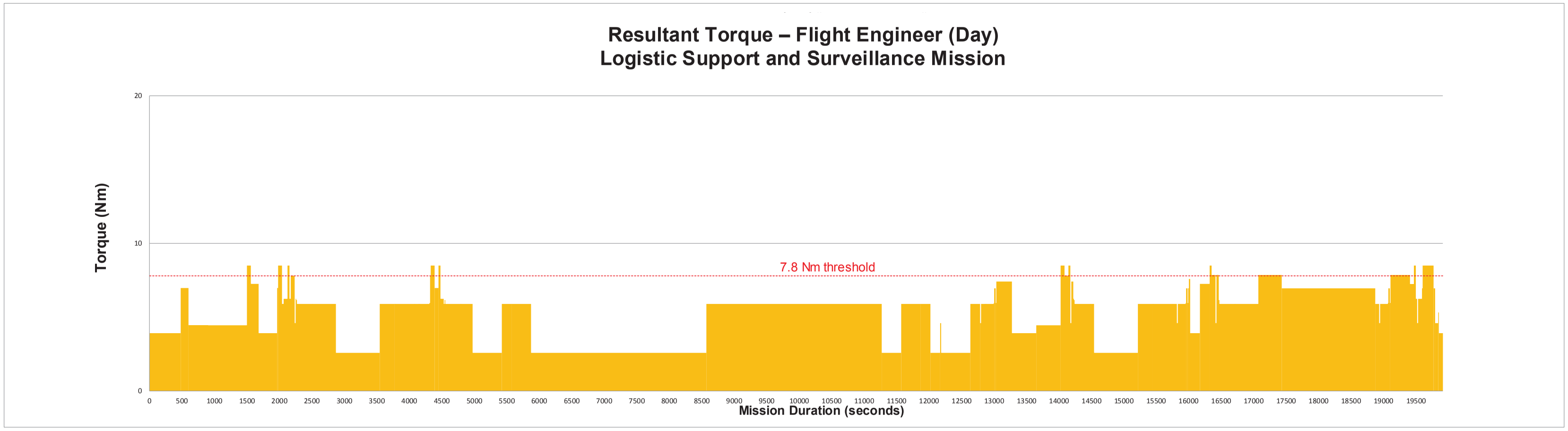

Figure 58: Logistic Support and Surveillance Mission – Fight Engineer (Day) Resultant Torque

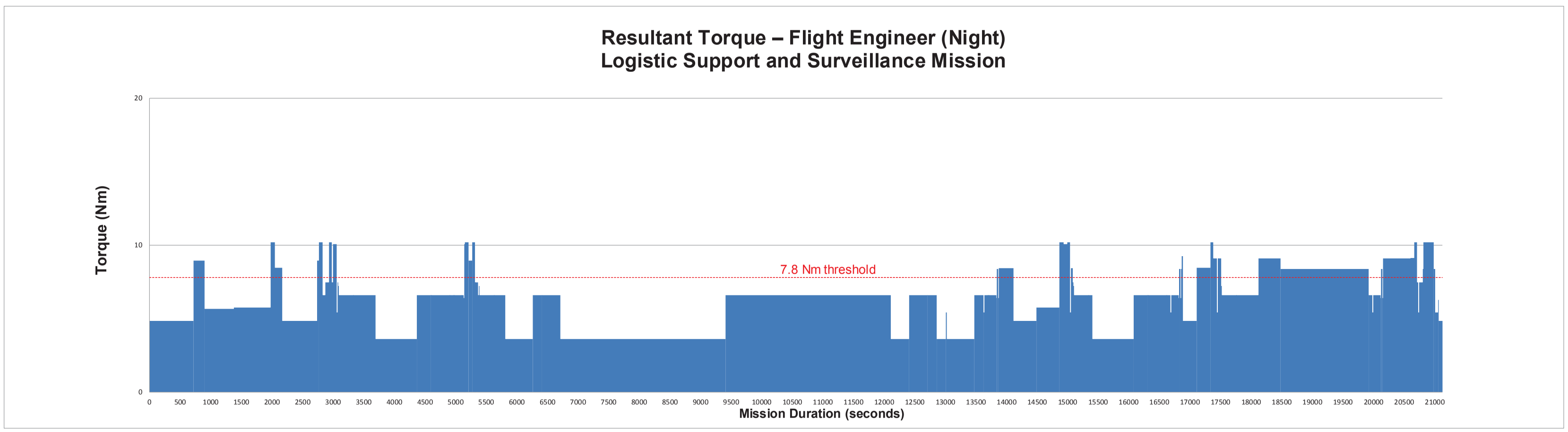

Figure 59: Logistic Support and Surveillance Mission – Fight Engineer (Night) Resultant Torque

Vignette 2 – Slung Load Training Mission

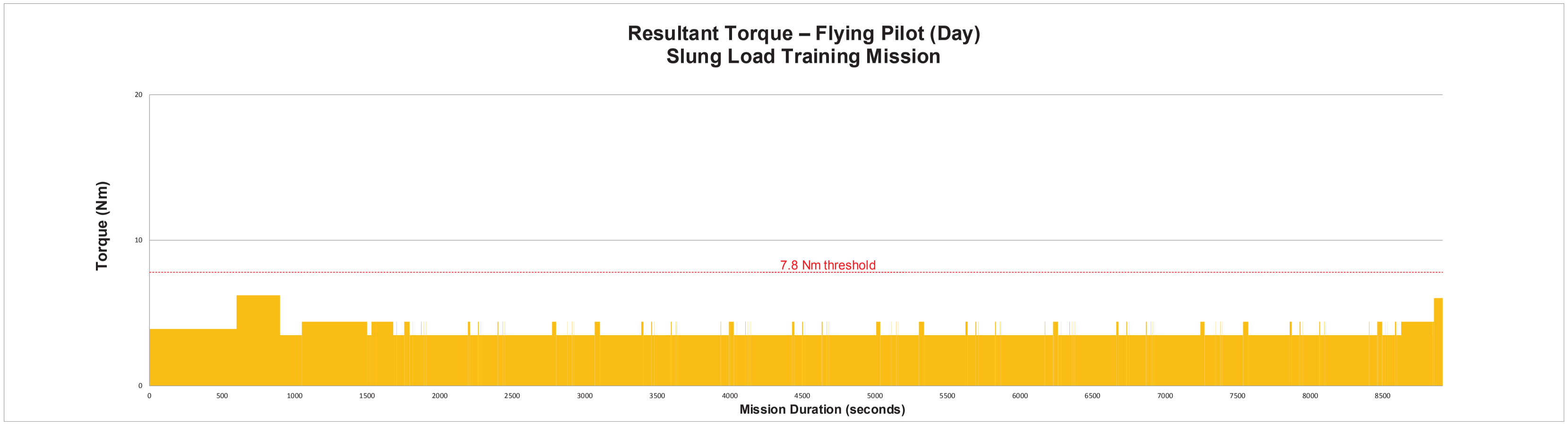

Figure 60: Slung Load Training Mission – Flying Pilot (Day) Resultant Torque

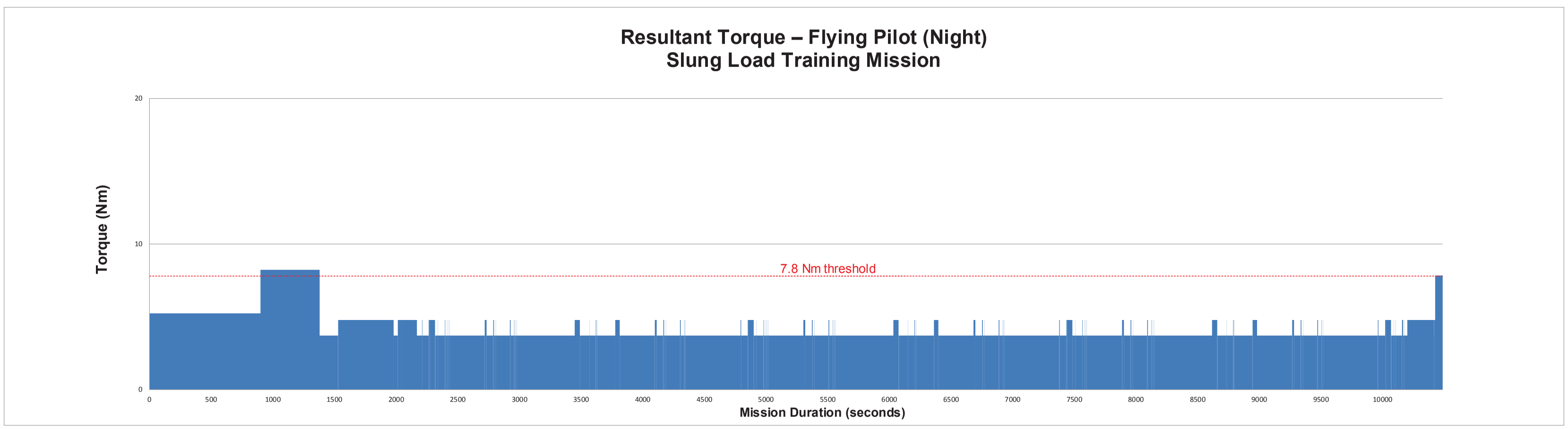

Figure 61: Slung Load Training Mission – Flying Pilot (Night) Resultant Torque

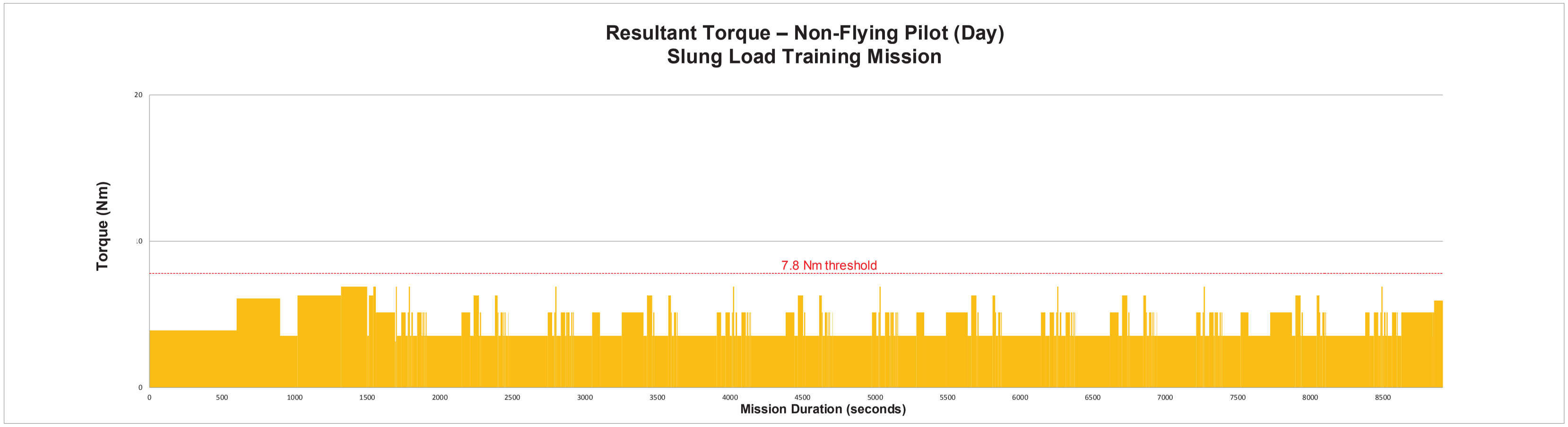

Figure 62: Slung Load Training Mission – Non-Flying Pilot (Day) Resultant Torque

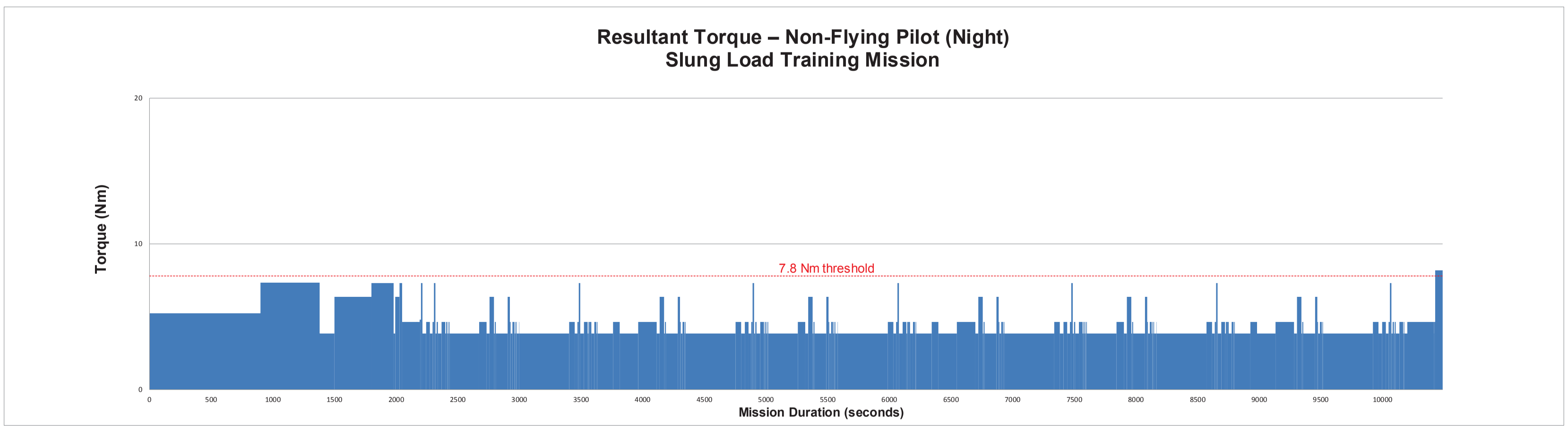

Figure 63: Slung Load Training Mission – Non-Flying Pilot (Night) Resultant Torque

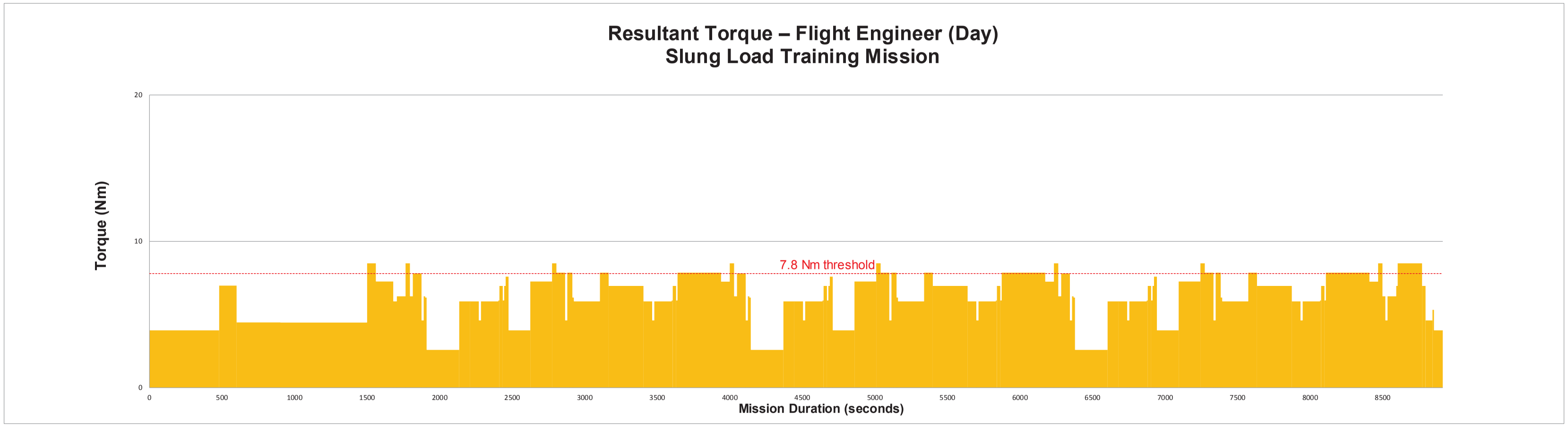

Figure 64: Slung Load Training Mission – Fight Engineer (Day) Resultant Torque

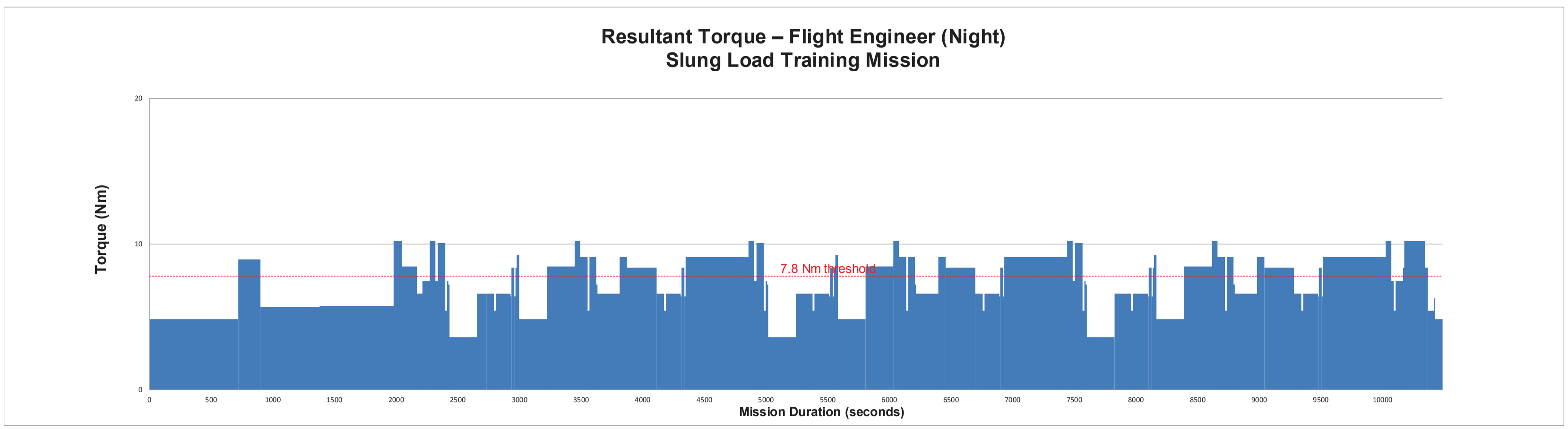

Figure 65: Slung Load Training Mission – Fight Engineer (Night) Resultant Torque

DRDC No. CR-2014-XXX

GRIFFON HELICOPTER NECK STRAIN PROJECT: PART 2: PHYSICAL DEMANDS ANALYSIS LIBRARY

by:

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PWGSC Contract No. W7711-088136/001/TOR
Task Authorization No. 4501101761, 8136-55

On Behalf of

Department of National Defence

As represented by

Human Systems Integration Section
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Scientific Authority

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Table of Contents

Flight Engineer

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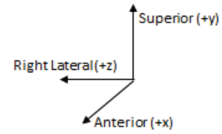
2-Full Check - Day

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	2-Full Check (FE)
DAY	
Participant # Sample Graphs:	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet Only



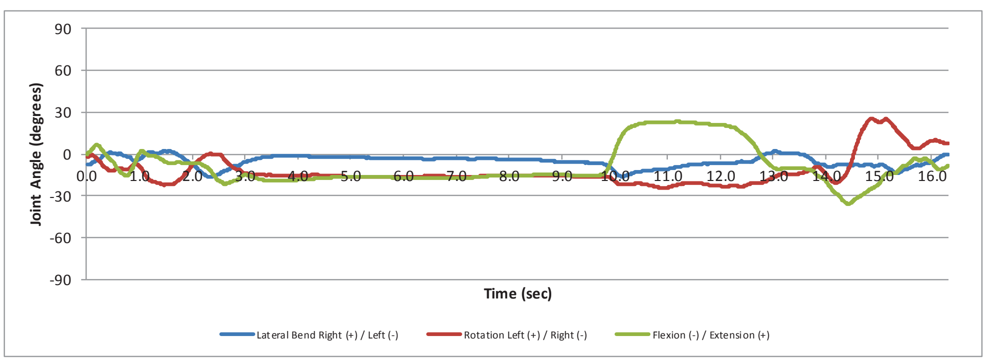
Task Description:	**Equipment Considerations:**
Kneeling in the front cabin position, the FE scans the dash gauges, the CDU console, and the ceiling breakers, switches, and dials.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:


Photograph


MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	29.058	seconds

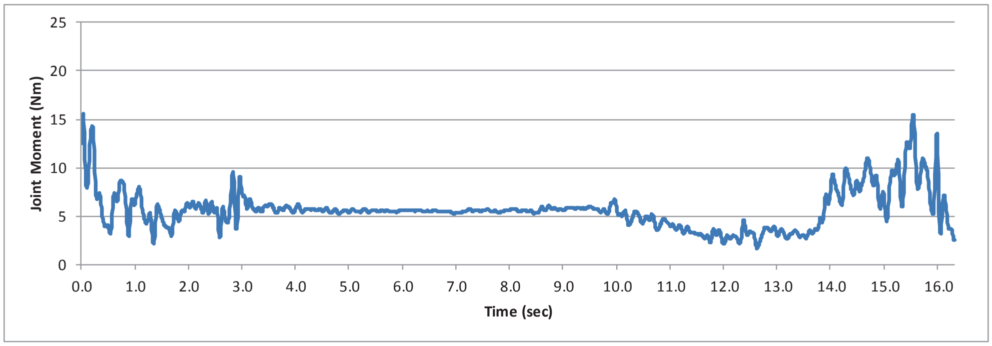
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	64.51	54.20	1575.32
Tension (N)	NA	NA	NA
Anterior Shear (N)	44.74	9.38	22.19
Posterior Shear (N)	-73.06	-19.97	-541.10
Right Lateral Shear (N)	46.74	8.44	97.02
Left Lateral Shear (N)	-52.66	-9.37	-197.60
Torque (Resultant) (Nm)	13.53	4.60	133.57
Right Lateral Moment (+Mx) (Nm)	6.39	1.76	13.68
Left Lateral Moment (-Mx) (Nm)	-6.30	-1.66	-35.46
Left Axial Moment (+My) (Nm)	3.47	0.60	10.43
Right Axial Moment (-My) (Nm)	-2.34	-0.52	-9.06
Extension Moment (+Mz) (Nm)	10.98	3.96	101.85
Flexion Moment (-Mz) (Nm)	-5.63	-1.36	-6.79

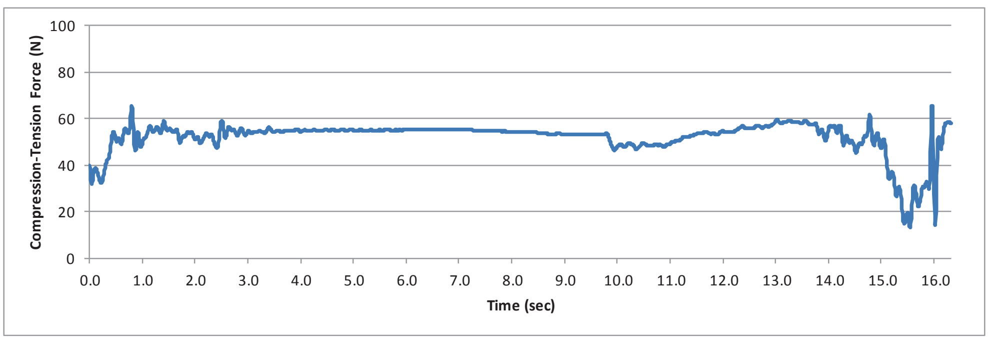
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	16.04	7.61
Left Lateral Bend	-10.45	-6.62
Left Axial Rotation	20.46	7.54
Right Axial Rotation	-42.16	-26.92
Extension	21.06	9.01
Flexion	-34.25	-11.05

2-Full Check - Day

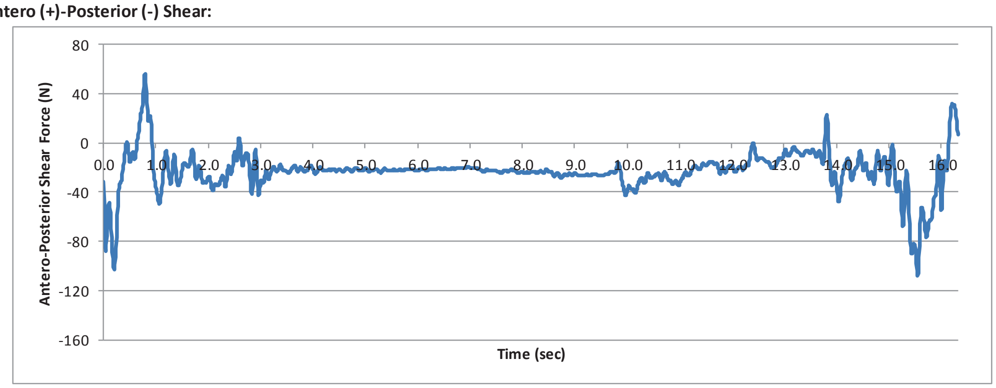
Resultant Neck Torque:



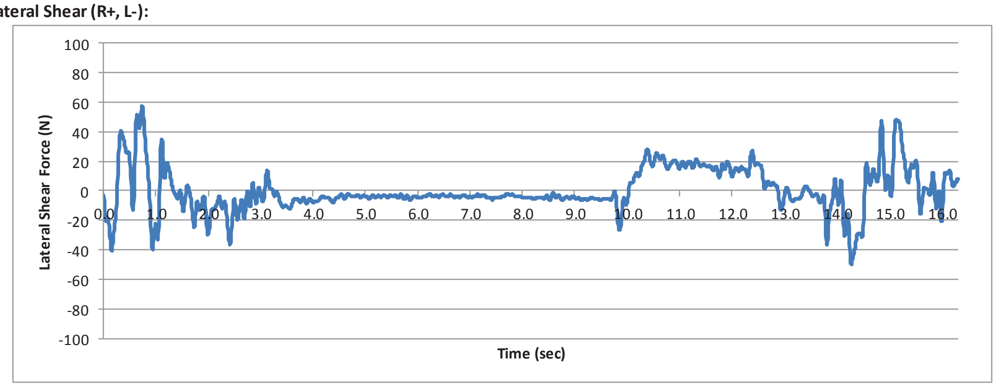
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



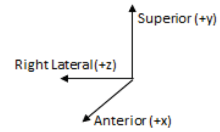
Lateral Shear (R+, L-):



2-Full Check - Night

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	2-Full Check (FE)
NIGHT	
Participant # Sample Graphs:	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



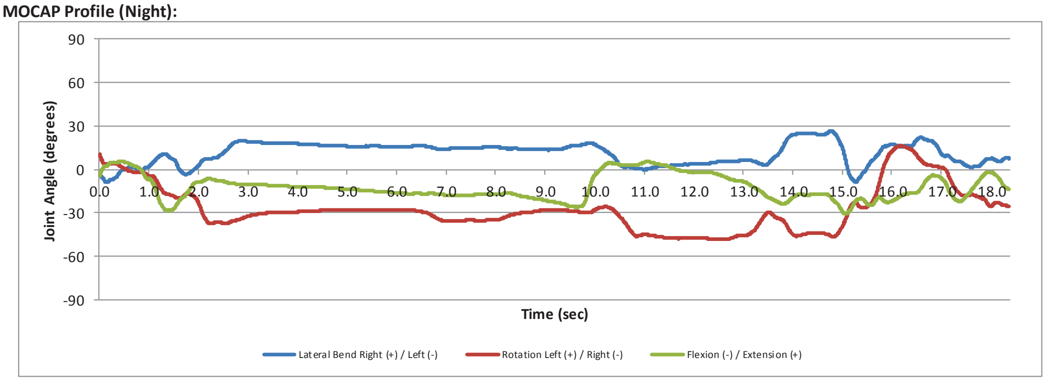
Task Description:	**Equipment Considerations:**
Kneeling in the front cabin position, the FE scans the dash gauges, the CDU console, and the ceiling breakers, switches, and dials.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	21.230	seconds

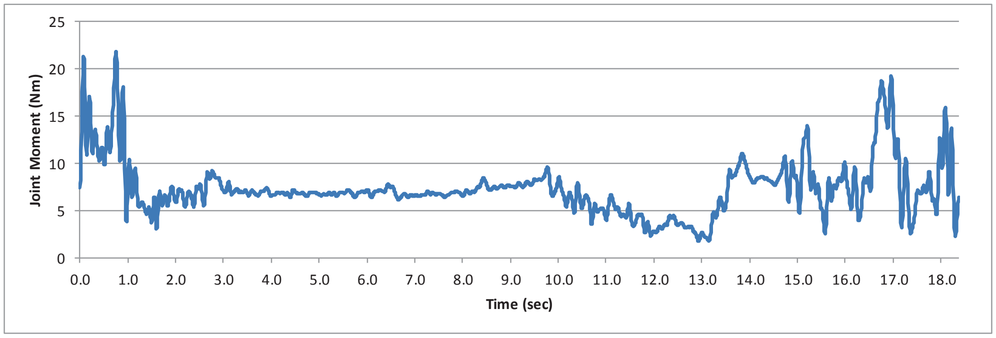
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	76.48	66.78	1418.37
Tension (N)	NA	NA	NA
Anterior Shear (N)	26.98	8.43	28.04
Posterior Shear (N)	-76.82	-22.45	-402.06
Right Lateral Shear (N)	47.69	10.83	127.89
Left Lateral Shear (N)	-38.75	-9.20	-108.48
Torque (Resultant) (Nm)	10.93	5.42	95.97
Right Lateral Moment (+Mx) (Nm	6.93	2.05	19.30
Left Lateral Moment (-Mx) (Nm)	-5.49	-2.08	-24.62
Left Axial Moment (+My) (Nm)	2.33	0.52	4.64
Right Axial Moment (-My) (Nm)	-4.08	-0.73	-8.95
Extension Moment (+Mz) (Nm)	11.86	4.37	84.33
Flexion Moment (-Mz) (Nm)	-5.00	-3.15	-10.21

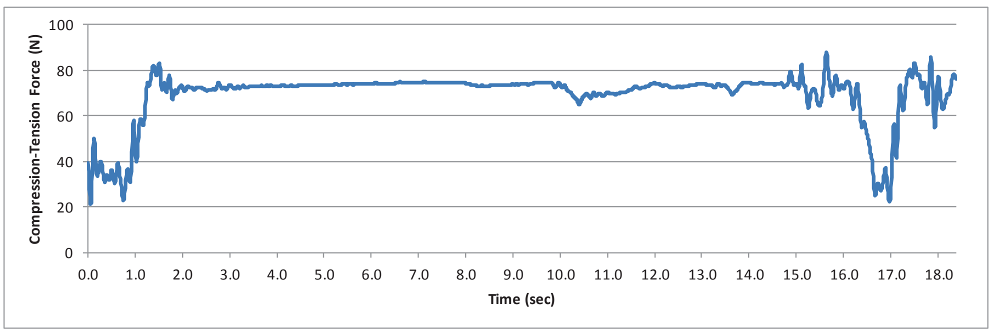
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	20.15	10.10
Left Lateral Bend	-12.54	-6.19
Left Axial Rotation	20.91	14.41
Right Axial Rotation	-32.02	-17.00
Extension	16.55	11.81
Flexion	-27.06	-12.37

2-Full Check - Night

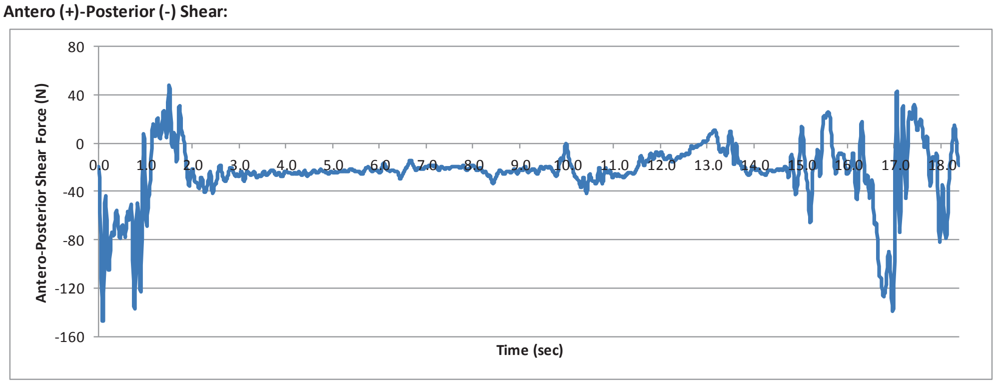
Resultant Neck Torque:



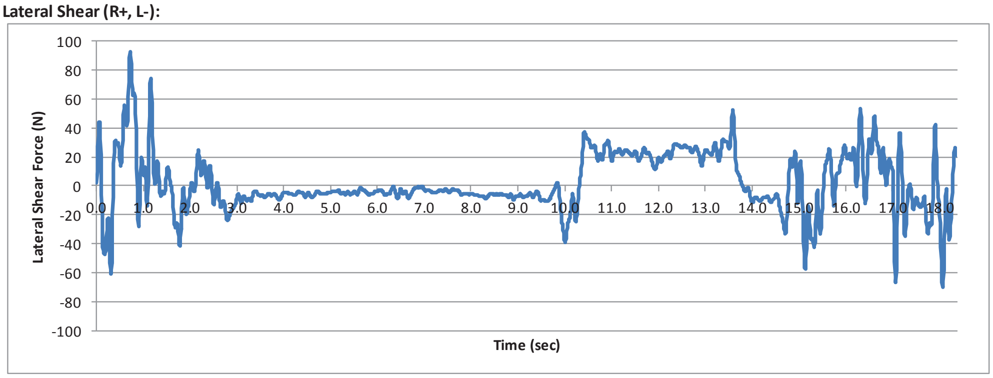
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



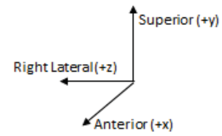
Lateral Shear (R+, L-):



Door Closing Outside - Day

Griffon MFTA - PDA: Postural Sequence

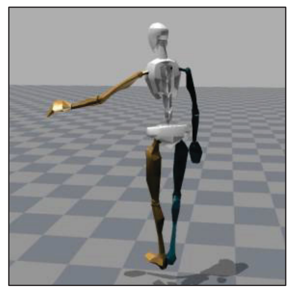
Postural Sequence:	Door Closing Outside (FE)
DAY	
Participant # (Sample Graphs):	FE01
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
Outside the AC, the FE closes the cabin door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Average Continuous Closing Door Force - 10.4 N Average Peak Closing Door Force -13.6 N

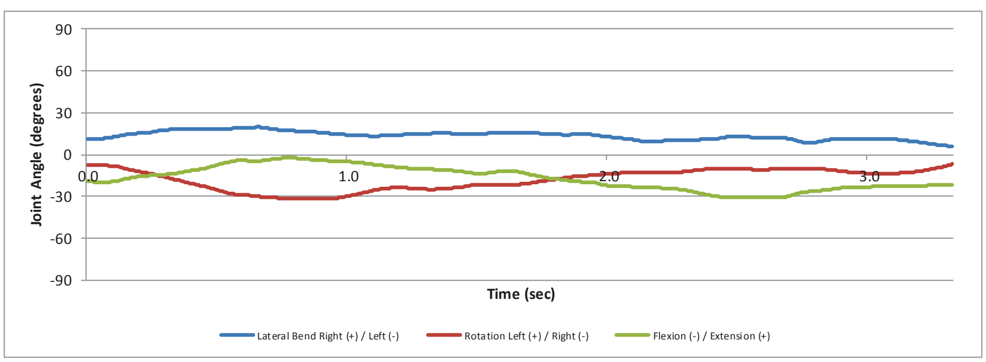
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	3.383	seconds

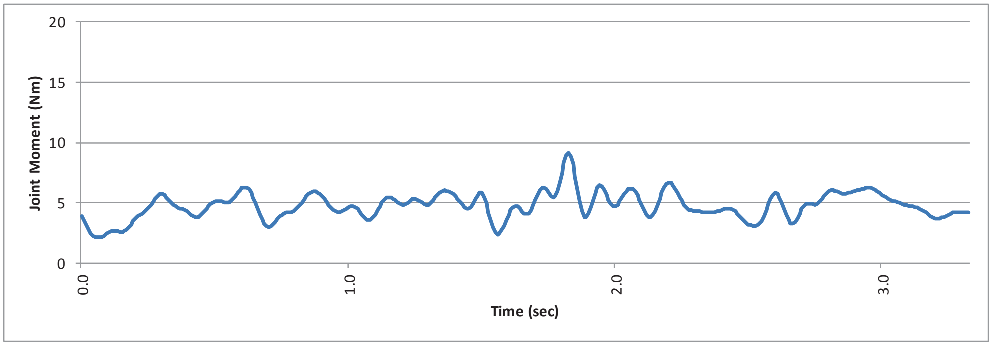
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	64.97	56.33	191.05
Tension (N)	NA	NA	NA
Anterior Shear (N)	22.47	8.16	5.64
Posterior Shear (N)	-42.74	-15.68	-42.34
Right Lateral Shear (N)	37.91	11.28	16.43
Left Lateral Shear (N)	-41.36	-13.65	-26.41
Torque (Resultant) (Nm)	9.69	5.32	18.04
Right Lateral Moment (+Mx) (Nm)	2.79	1.03	0.74
Left Lateral Moment (-Mx) (Nm)	-6.08	-2.46	-6.57
Left Axial Moment (+My) (Nm)	2.18	0.64	0.90
Right Axial Moment (-My) (Nm)	-2.88	-0.85	-1.67
Extension Moment (+Mz) (Nm)	7.77	4.00	12.90
Flexion Moment (-Mz) (Nm)	-2.36	-0.82	-0.27

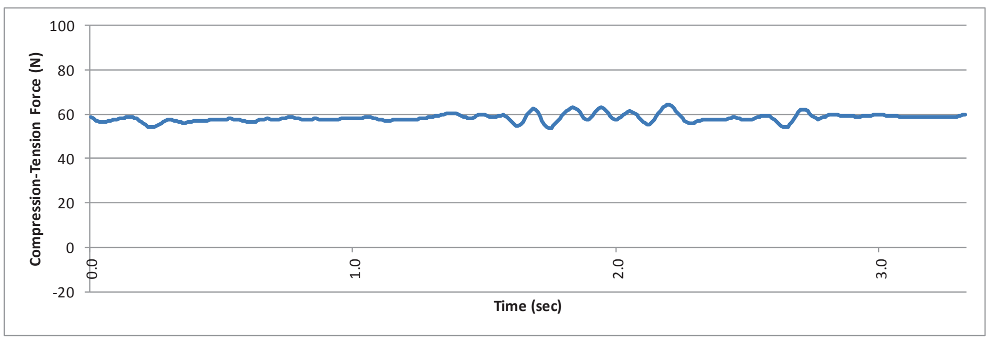
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	20.37	11.22
Left Lateral Bend	-3.86	-2.61
Left Axial Rotation	13.54	7.37
Right Axial Rotation	-35.59	-22.11
Extension	2.43	1.48
Flexion	-25.00	-16.32

Door Closing Outside – Day

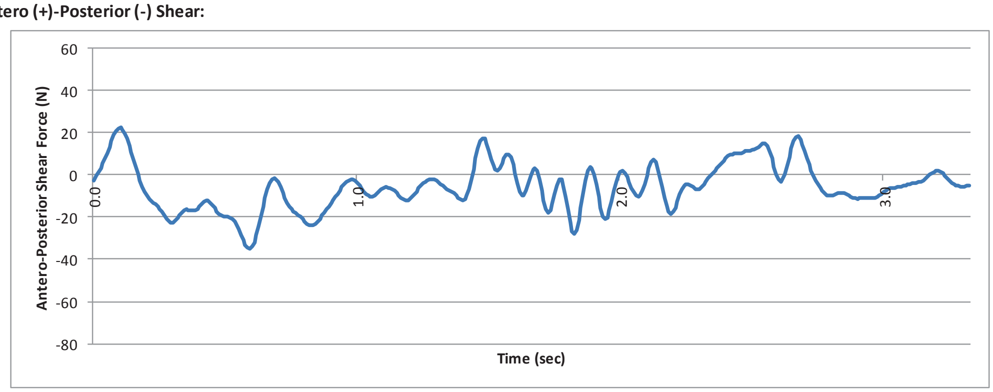
Resultant Neck Torque:



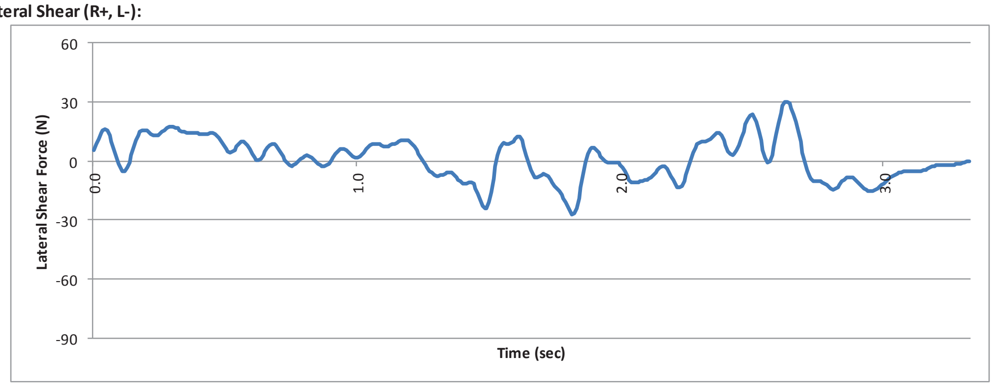
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



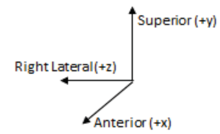
Lateral Shear (R+, L-):



Door Closing Outside – Night

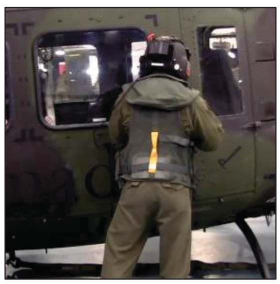
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Door Closing Outside (FE)
NIGHT	
Participant # (Sample Graphs):	FE01
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG

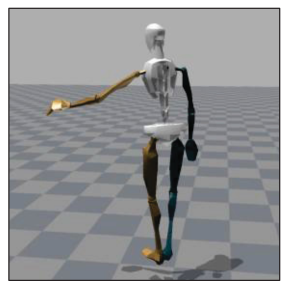


Task Description:	**Equipment Considerations:**
Outside the AC, the FE closes the cabin door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Average Continuous Closing Door Force - 10.4 N Average Peak Closing Door Force -13.6 N

Image:

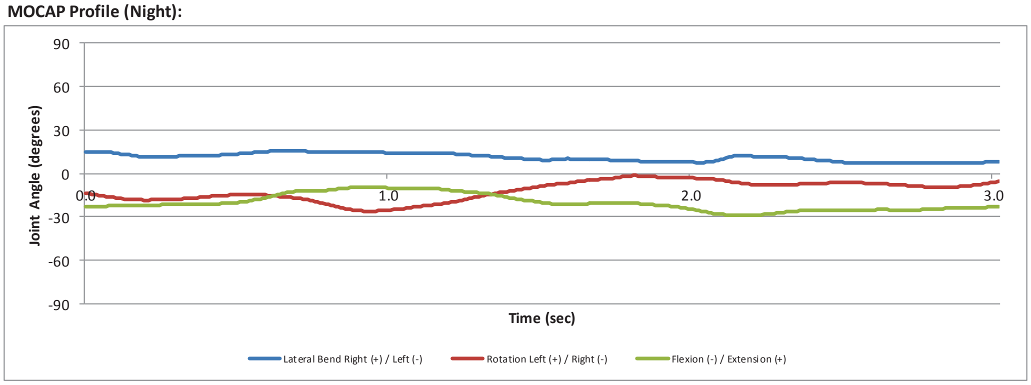


Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



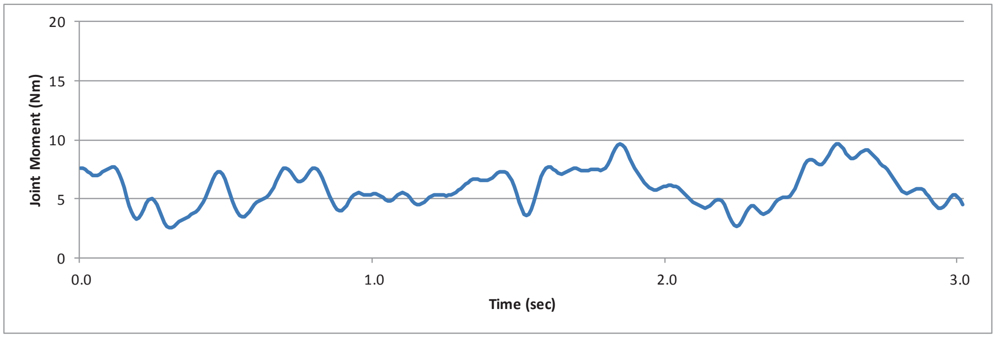
Posture Duration:	3.140	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

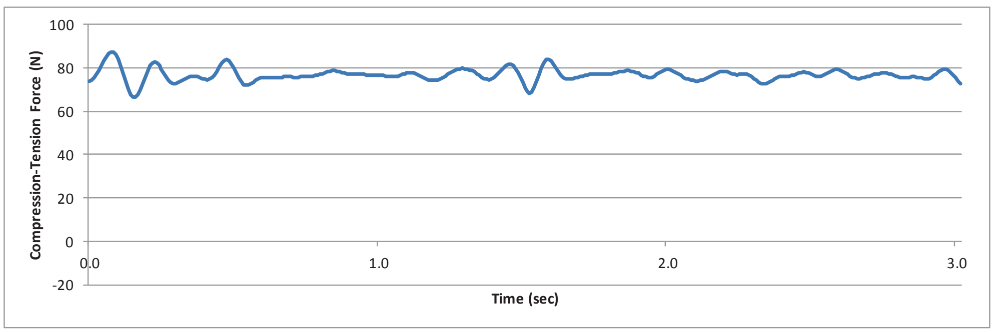
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	82.04	70.35	221.51	Right Lateral Bend	13.80	9.02
Tension (N)	NA	NA	NA	Left Lateral Bend	-15.41	-9.14
Anterior Shear (N)	24.53	9.10	6.65	Left Axial Rotation	41.43	28.11
Posterior Shear (N)	-48.18	-18.40	-44.48	Right Axial Rotation	-20.87	-11.83
Right Lateral Shear (N)	35.29	11.71	13.58	Extension	3.85	2.18
Left Lateral Shear (N)	-46.46	-18.16	-36.12	Flexion	-22.46	-14.62
Torque (Resultant) (Nm)	10.84	6.28	19.77			
Right Lateral Moment (+Mx) (Nm	4.32	2.35	2.25			
Left Lateral Moment (-Mx) (Nm)	-6.11	-2.58	-5.66			
Left Axial Moment (+My) (Nm)	2.40	0.94	1.68			
Right Axial Moment (-My) (Nm)	-2.51	-0.87	-1.20			
Extension Moment (+Mz) (Nm)	9.19	4.77	14.55			
Flexion Moment (-Mz) (Nm)	-1.90	-0.89	-0.17			

Door Closing Outside – Night

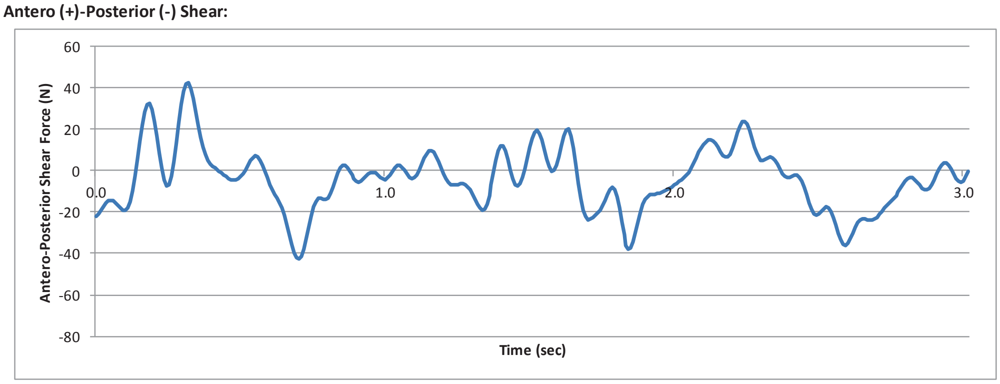
Resultant Neck Torque:



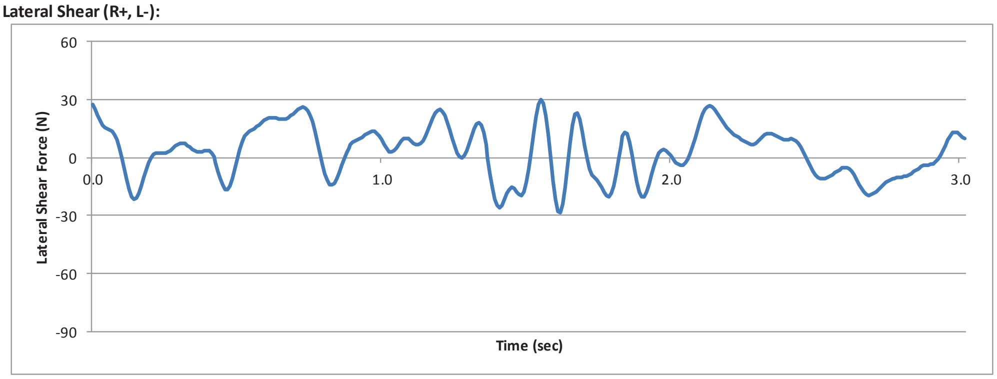
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



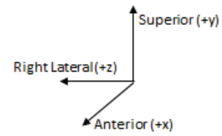
Lateral Shear (R+, L-):



Door Closing Seated – Day

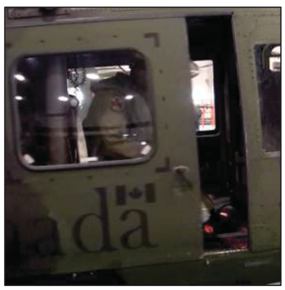
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Door Closing Seated (FE)
DAY	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet Only

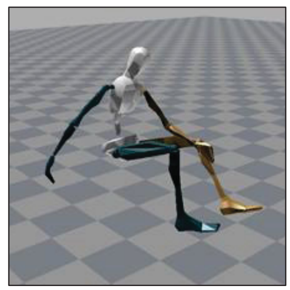


Task Description:	**Equipment Considerations:**
In the jump seat facing forward, the FE closes the cabin door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Average Continuous Closing Door Force - 10.4 N Average Peak Closing Door Force -13.6 N

Image:

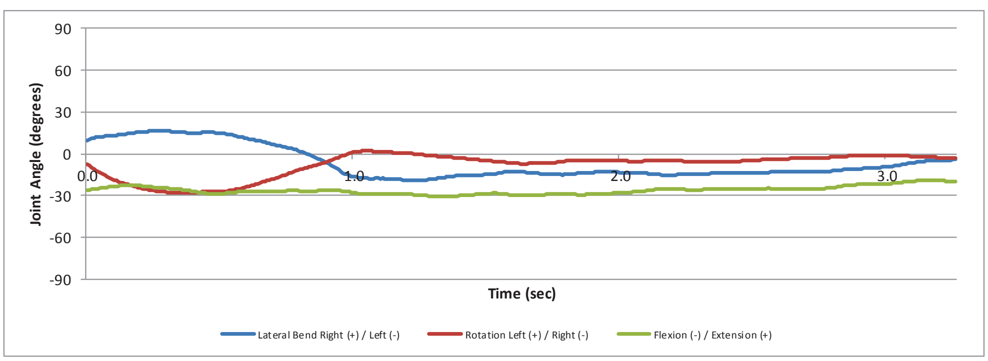


Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



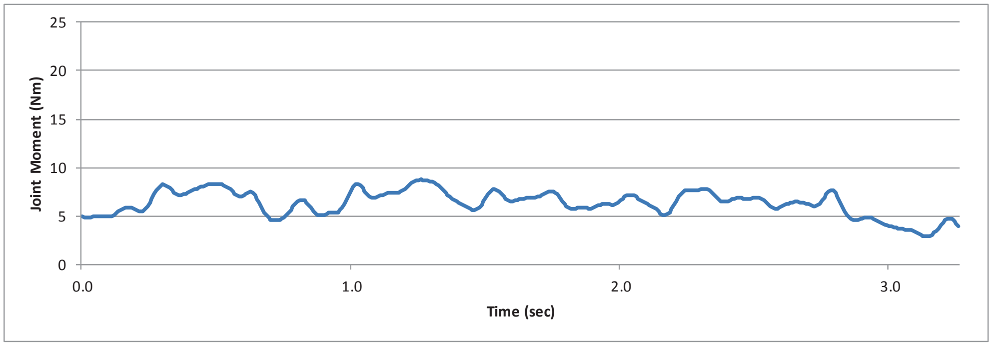
Posture Duration:	3.867	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

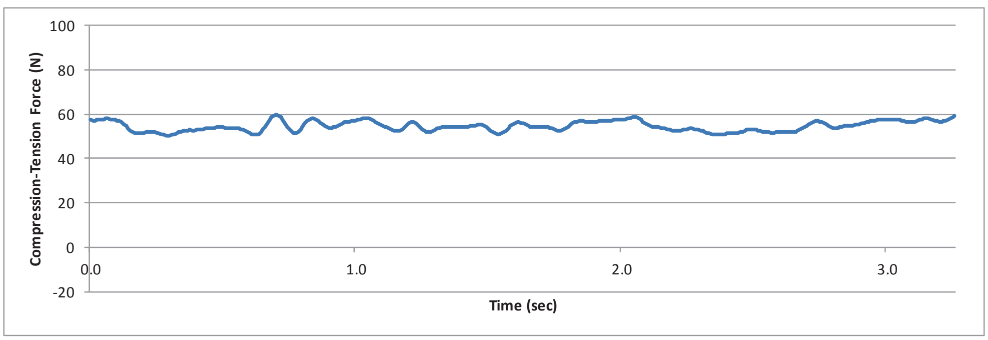
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	62.66	54.54	211.36	Right Lateral Bend	17.04	12.10
Tension (N)	NA	NA	NA	Left Lateral Bend	-13.74	-8.05
Anterior Shear (N)	16.48	11.08	5.17	Left Axial Rotation	1.98	1.13
Posterior Shear (N)	-48.47	-20.86	-71.10	Right Axial Rotation	-50.47	-32.92
Right Lateral Shear (N)	38.70	13.63	26.58	Extension	NA	NA
Left Lateral Shear (N)	-28.79	-10.45	-20.12	Flexion	-33.08	-21.52
Torque (Resultant) (Nm)	11.83	6.16	23.86			
Right Lateral Moment (+Mx) (Nm)	4.44	1.79	3.13			
Left Lateral Moment (-Mx) (Nm)	-3.93	-2.18	-4.62			
Left Axial Moment (+My) (Nm)	2.00	0.75	1.38			
Right Axial Moment (-My) (Nm)	-3.70	-1.22	-2.50			
Extension Moment (+Mz) (Nm)	8.89	5.16	19.72			
Flexion Moment (-Mz) (Nm)	-1.19	-0.91	-0.14			

Door Closing Seated – Day

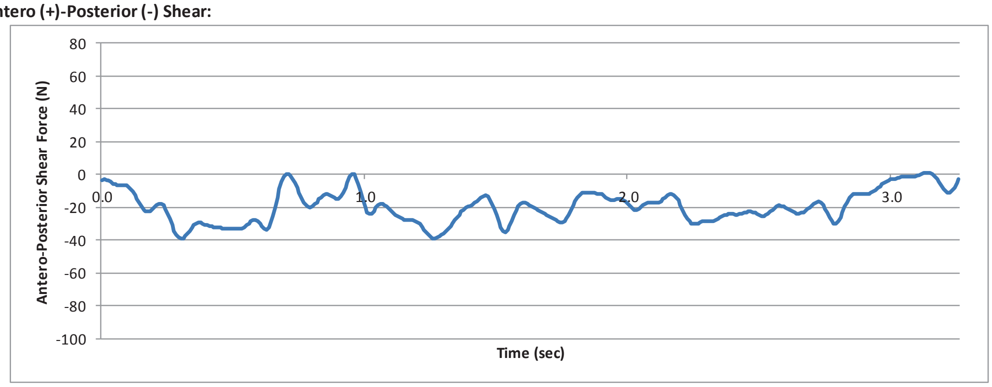
Resultant Neck Torque:



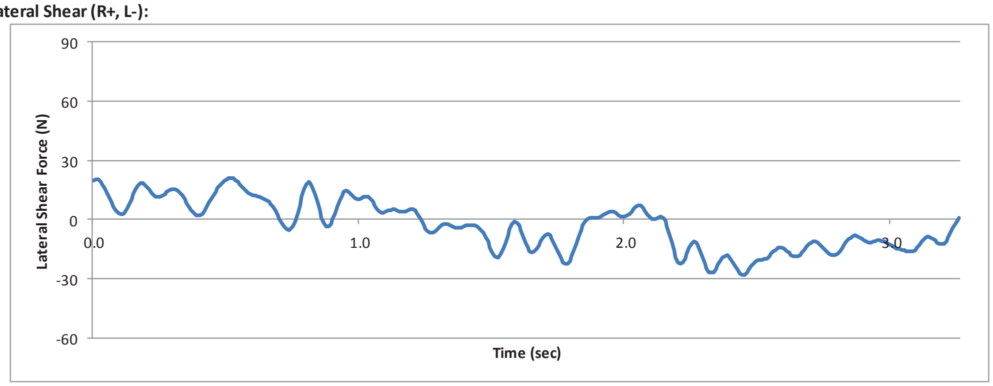
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



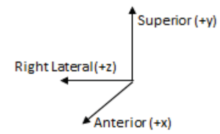
Lateral Shear (R+, L-):



Door Closing Seated – Night

Griffon MFTA - PDA: Postural Sequence

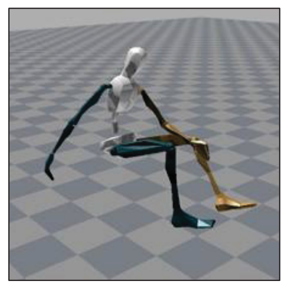
Postural Sequence:	Door Closing Seated (FE)
NIGHT	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
In the jump seat facing forward, the FE closes the cabin door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Average Continuous Closing Door Force - 10.4 N Average Peak Closing Door Force -13.6 N

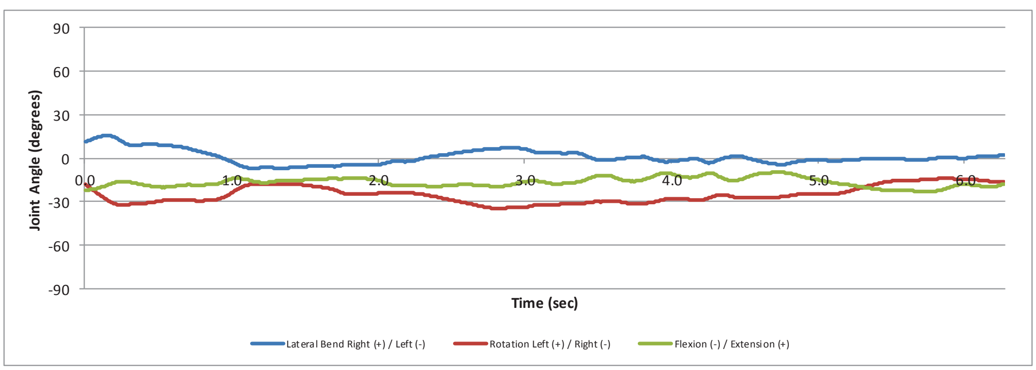
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



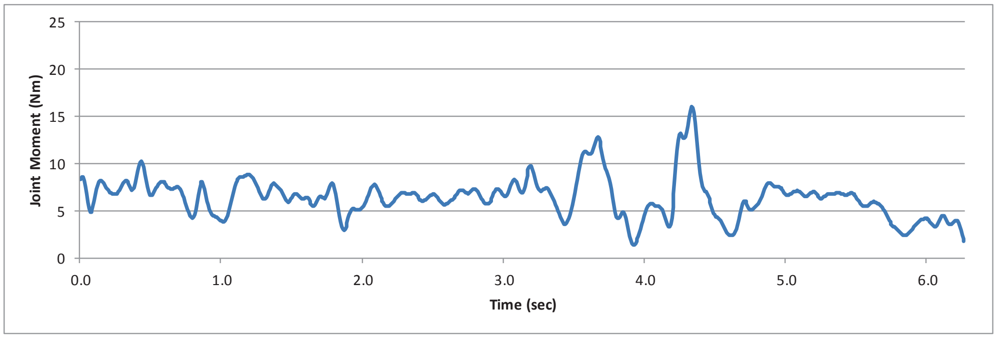
Posture Duration:	4.297	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

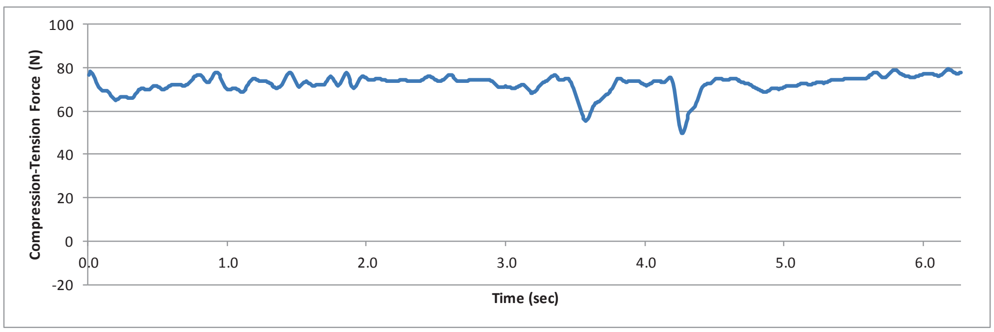
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	76.63	68.17	293.48	Right Lateral Bend	17.01	7.74
Tension (N)	NA	NA	NA	Left Lateral Bend	-13.46	-7.64
Anterior Shear (N)	35.52	12.10	7.36	Left Axial Rotation	2.73	1.36
Posterior Shear (N)	-72.12	-26.67	-101.83	Right Axial Rotation	-35.50	-19.11
Right Lateral Shear (N)	47.77	14.40	32.34	Extension	3.25	1.83
Left Lateral Shear (N)	-43.03	-13.31	-27.42	Flexion	-29.47	-18.21
Torque (Resultant) (Nm)	10.93	7.22	25.92			
Right Lateral Moment (+Mx) (Nm	5.46	2.13	3.93			
Left Lateral Moment (-Mx) (Nm)	-6.57	-2.00	-4.92			
Left Axial Moment (+My) (Nm)	2.77	0.77	1.86			
Right Axial Moment (-My) (Nm)	-3.22	-1.07	-2.01			
Extension Moment (+Mz) (Nm)	12.03	6.37	27.11			
Flexion Moment (-Mz) (Nm)	-1.08	-1.08	-0.13			

Door Closing Seated – Night

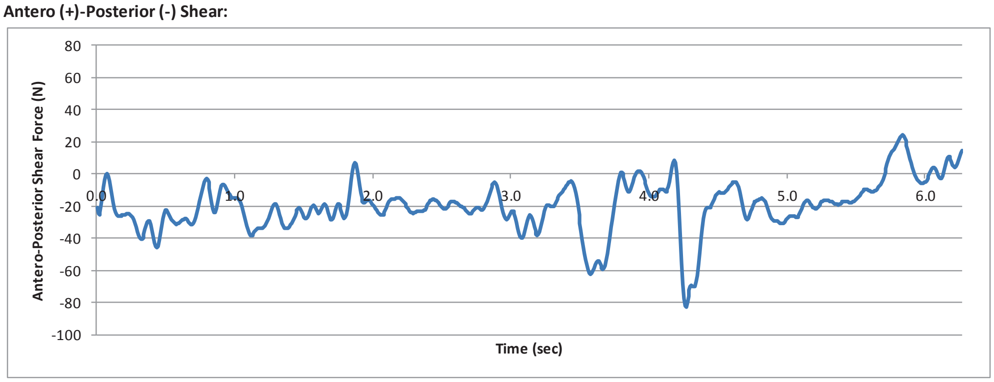
Resultant Neck Torque:



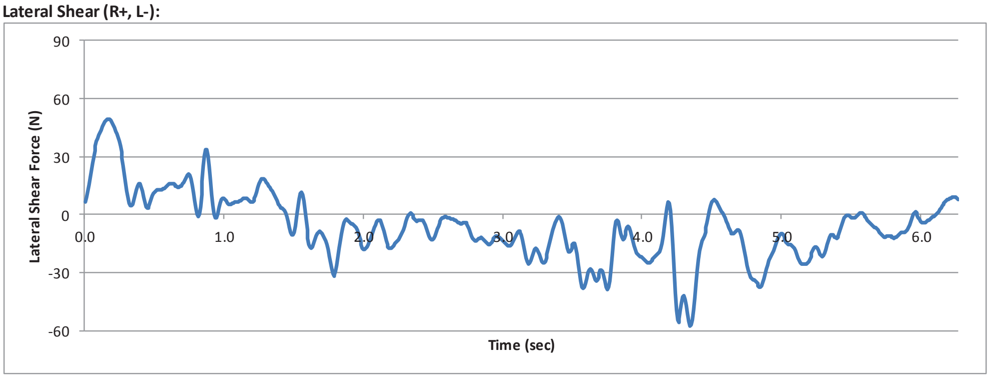
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



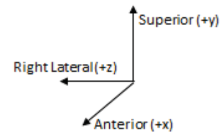
Lateral Shear (R+, L-):



Door Opening Inside - Day

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Door Opening Inside (FE)
DAY	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet Only



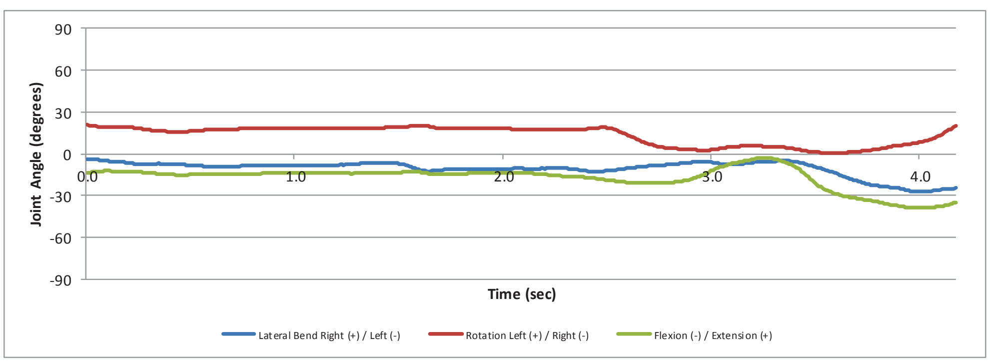
Task Description:	Equipment Considerations:
FE adopts door opening position from inside, scans the dash gauge for air speed to confirm (<80 kts), and pulls the door open.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Average Continuous Door Force - Open - 11.6 N Average Peak Door Force - Open - 15.7 N

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	3.363	seconds

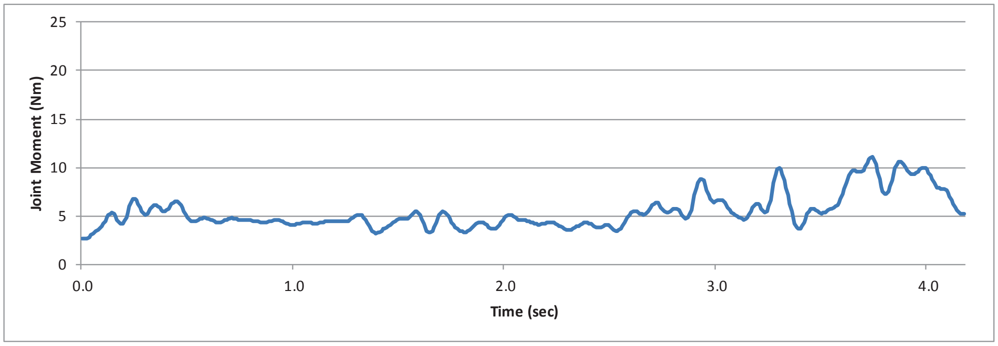
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	65.32	51.73	174.42
Tension (N)	NA	NA	NA
Anterior Shear (N)	23.82	8.63	4.13
Posterior Shear (N)	-65.20	-24.03	-69.51
Right Lateral Shear (N)	34.68	11.11	10.22
Left Lateral Shear (N)	-57.14	-16.79	-41.16
Torque (Resultant) (Nm)	9.81	5.96	16.74
Right Lateral Moment (+Mx) (Nm)	4.92	1.77	1.94
Left Lateral Moment (-Mx) (Nm)	-6.18	-1.80	-4.09
Left Axial Moment (+My) (Nm)	3.99	1.17	2.89
Right Axial Moment (-My) (Nm)	-1.97	-0.79	-0.71
Extension Moment (+Mz) (Nm)	10.14	5.04	16.33
Flexion Moment (-Mz) (Nm)	-2.11	-1.22	-0.40

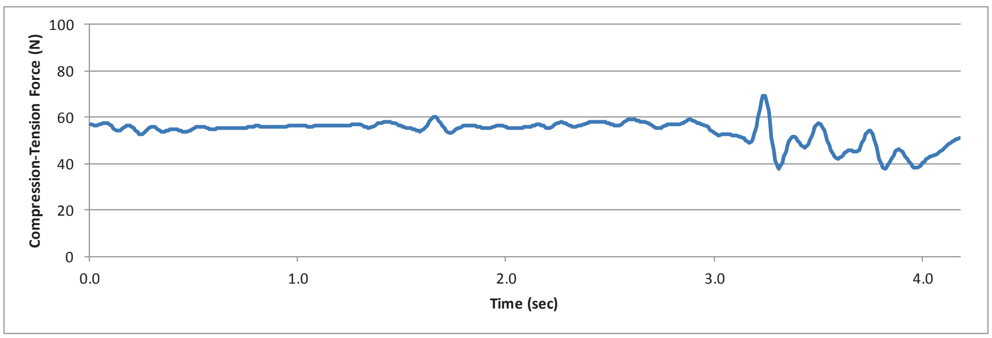
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	8.96	6.03
Left Lateral Bend	-13.47	-8.78
Left Axial Rotation	20.98	11.87
Right Axial Rotation	-37.40	-25.30
Extension	3.79	2.10
Flexion	-29.28	-18.19

Door Closing Inside – Day

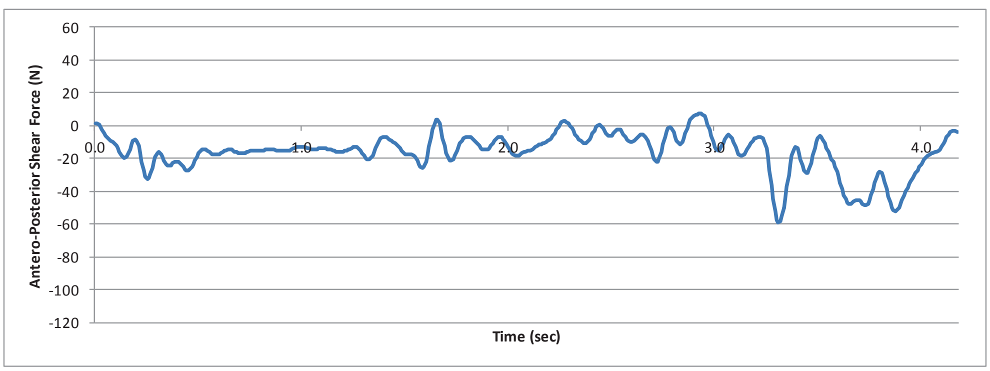
Resultant Neck Torque:



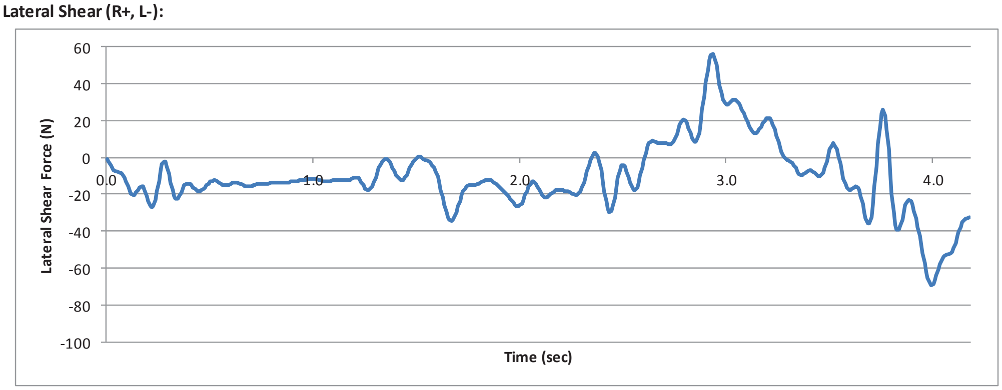
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



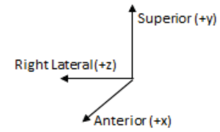
Lateral Shear (R+, L-):



Door Opening Inside – Night

Griffon MFTA - PDA: Postural Sequence

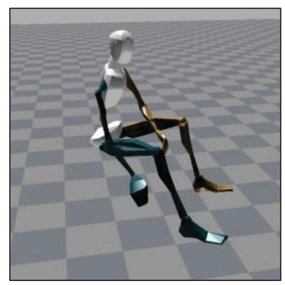
Postural Sequence:	Door Opening Inside (FE)
NIGHT	
Participant # (Sample Graphs:	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
FE adopts door opening position from inside, scans the dash gauge for air speed to confirm (<80 kts), and pulls the door open.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Average Continuous Door Force - Open - 11.6 N Average Peak Door Force - Open - 15.7 N

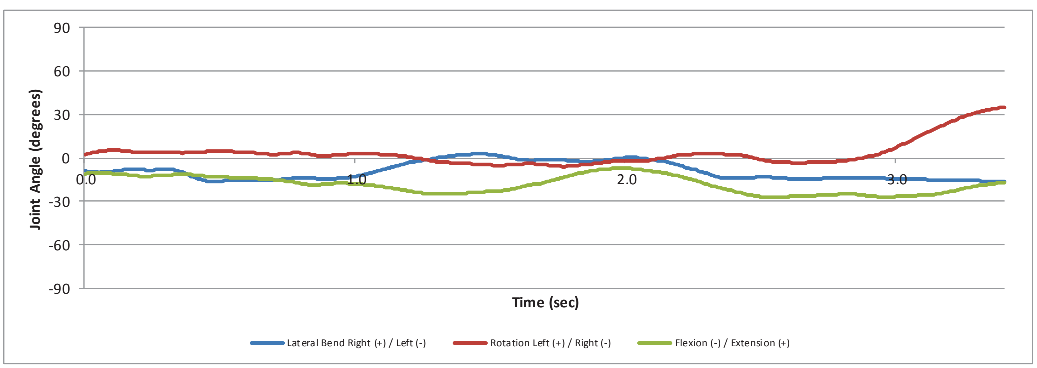
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	3.935	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

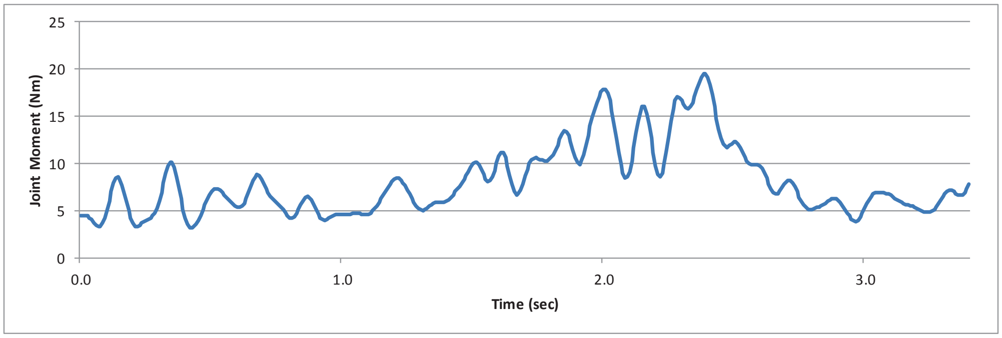
Force	Peak	Mean	Area
Compression (N)	80.68	65.54	258.44
Tension (N)	NA	NA	NA
Anterior Shear (N)	22.86	7.02	2.41
Posterior Shear (N)	-88.89	-26.24	-94.47
Right Lateral Shear (N)	34.78	11.83	15.70
Left Lateral Shear (N)	-53.66	-16.55	-43.30
Torque (Resultant) (Nm)	14.24	6.40	21.03
Right Lateral Moment (+Mx) (Nm	4.38	1.30	1.57
Left Lateral Moment (-Mx) (Nm)	-7.54	-2.63	-7.21
Left Axial Moment (+My) (Nm)	2.82	0.98	1.62
Right Axial Moment (-My) (Nm)	-2.75	-0.80	-1.84
Extension Moment (+Mz) (Nm)	12.78	5.12	19.11
Flexion Moment (-Mz) (Nm)	-1.17	-0.47	-0.13

ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	10.82	7.17
Left Lateral Bend	-10.24	-5.97
Left Axial Rotation	31.19	14.05
Right Axial Rotation	-41.39	-29.44
Extension	9.93	8.63
Flexion	-20.32	-11.08

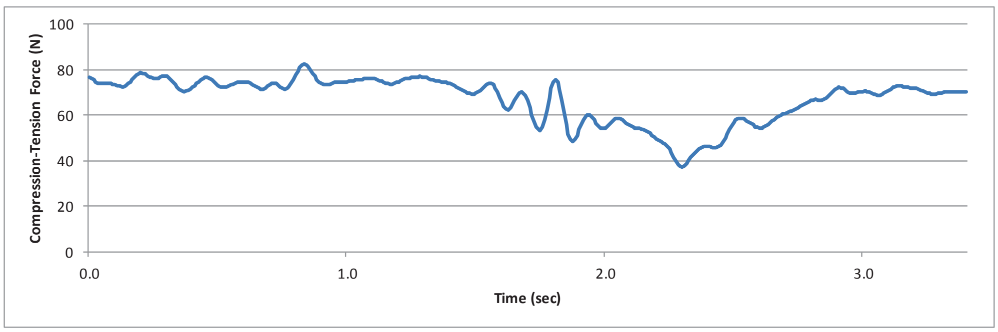
Door Closing Inside - Night

Door Closing Inside - Night

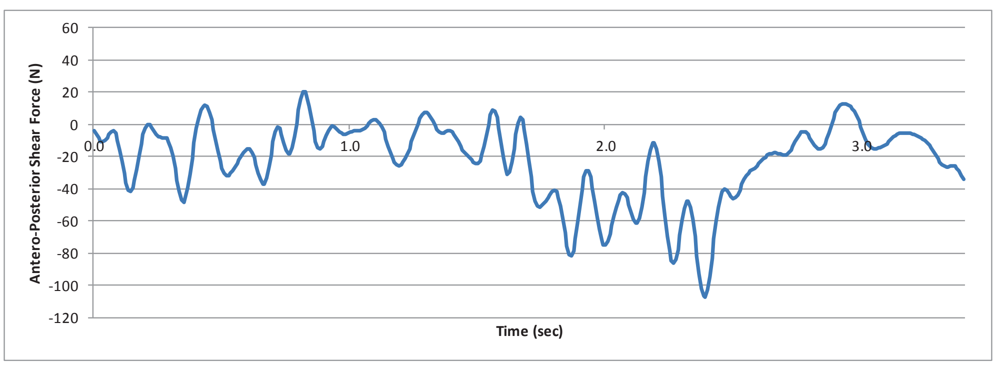
Resultant Neck Torque:



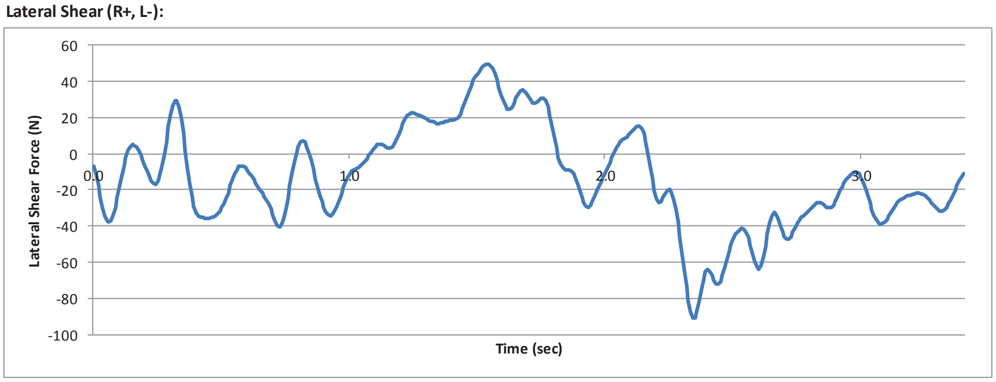
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



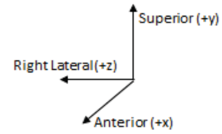
Lateral Shear (R+, L-):



Door Opening Outside - Day

Griffon MFTA - PDA: Postural Sequence

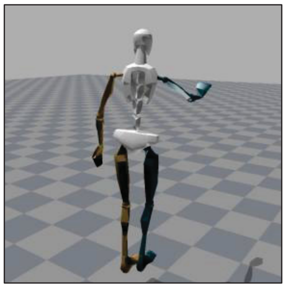
Postural Sequence:	Door Opening Outside (FE)
DAY	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet Only



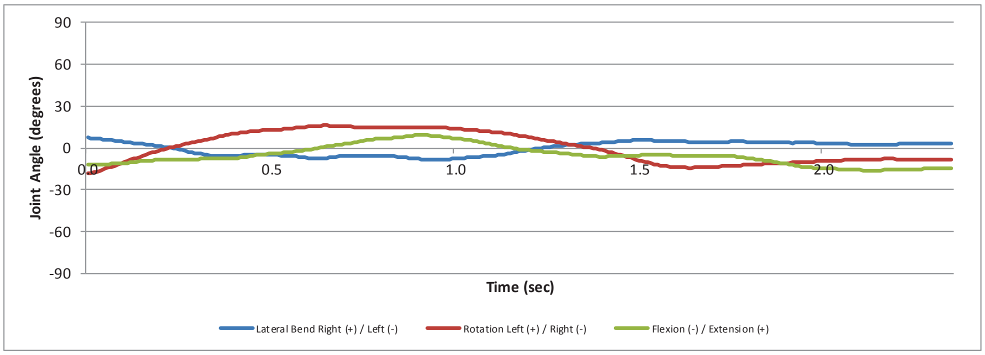
Task Description:	Equipment Considerations:
Outside the AC, the FE opens the cabin door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Average Continuous Opening Door Force - 11.6 N Average Peak Opening Door Force - 15.7 N

Image:


Photograph


MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	2.444	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

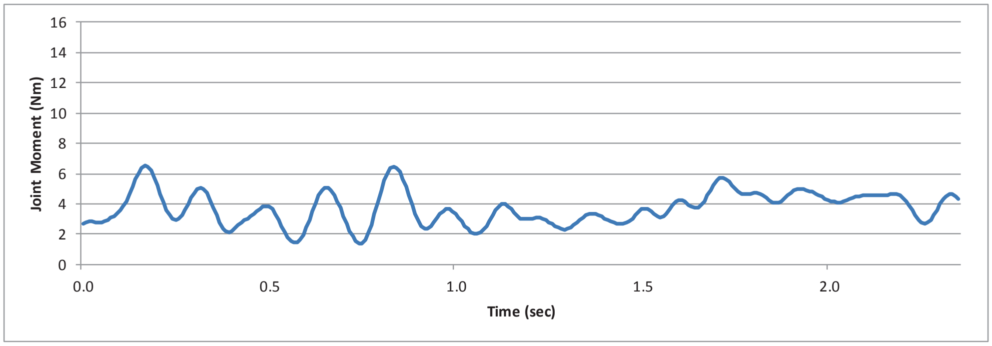
Force	Peak	Mean	Area
Compression (N)	63.77	58.31	143.01
Tension (N)	NA	NA	NA
Anterior Shear (N)	18.04	7.09	3.33
Posterior Shear (N)	-30.44	-11.32	-22.45
Right Lateral Shear (N)	18.01	6.30	5.99
Left Lateral Shear (N)	-27.43	-8.64	-12.98
Torque (Resultant) (Nm)	7.22	4.46	10.94
Right Lateral Moment (+Mx) (Nm)	2.36	1.09	0.64
Left Lateral Moment (-Mx) (Nm)	-4.09	-1.75	-3.44
Left Axial Moment (+My) (Nm)	0.93	0.31	0.32
Right Axial Moment (-My) (Nm)	-0.92	-0.36	-0.51
Extension Moment (+Mz) (Nm)	6.13	3.17	7.49
Flexion Moment (-Mz) (Nm)	-1.65	-0.83	-0.15

ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	10.65	7.99
Left Lateral Bend	-4.79	-3.07
Left Axial Rotation	10.55	7.41
Right Axial Rotation	-32.45	-23.59
Extension	7.78	3.56
Flexion	-18.06	-13.51

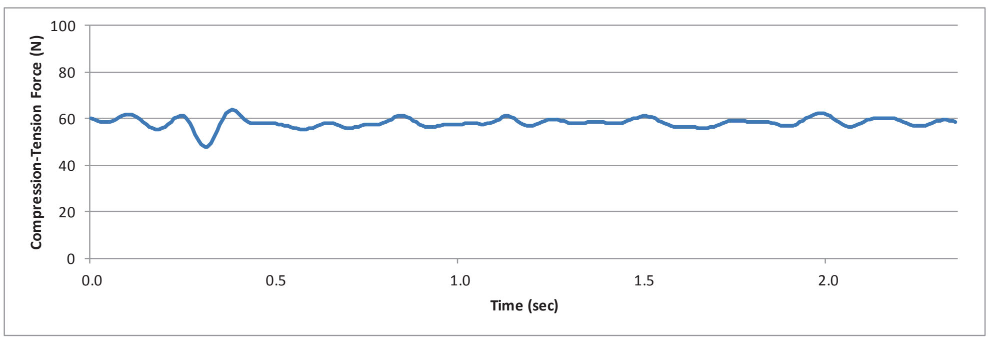
HUMANSYSTEMS Incorporated

Door Opening Outside - Day

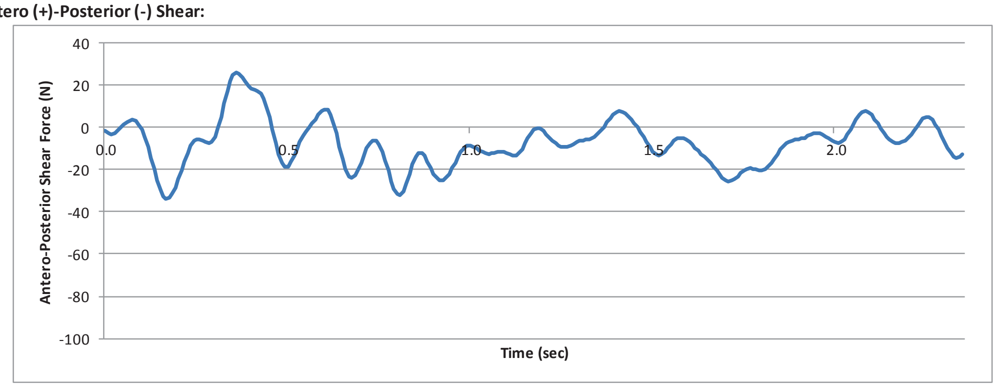
Resultant Neck Torque:



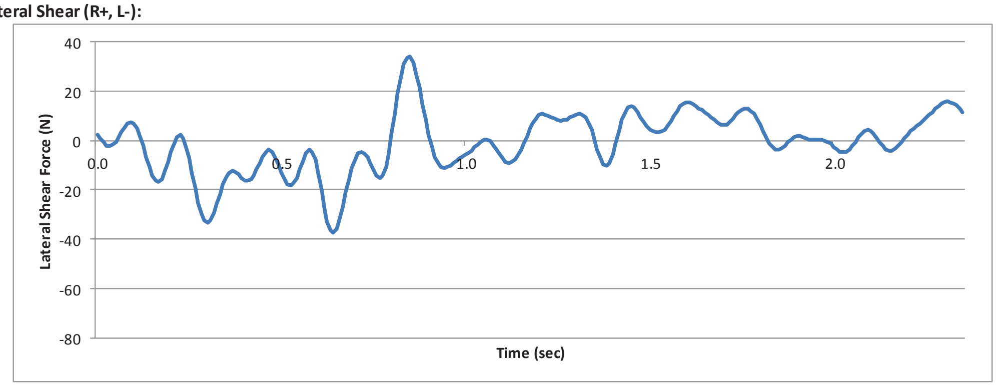
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



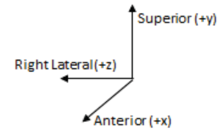
Lateral Shear (R+, L-):



Door Opening Outside - Night

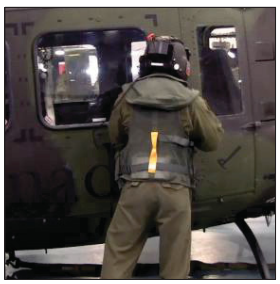
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Door Opening Outside (FE)
NIGHT	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG

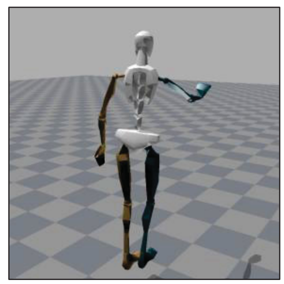


Task Description:	Equipment Considerations:
Outside the AC, the FE opens the cabin door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Average Continuous Opening Door Force - 11.6 N Average Peak Opening Door Force - 15.7 N

Image:

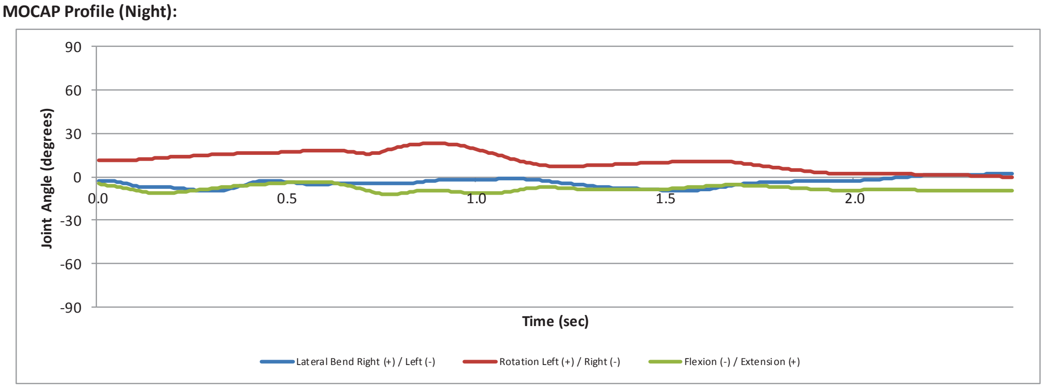


Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	2.232	seconds

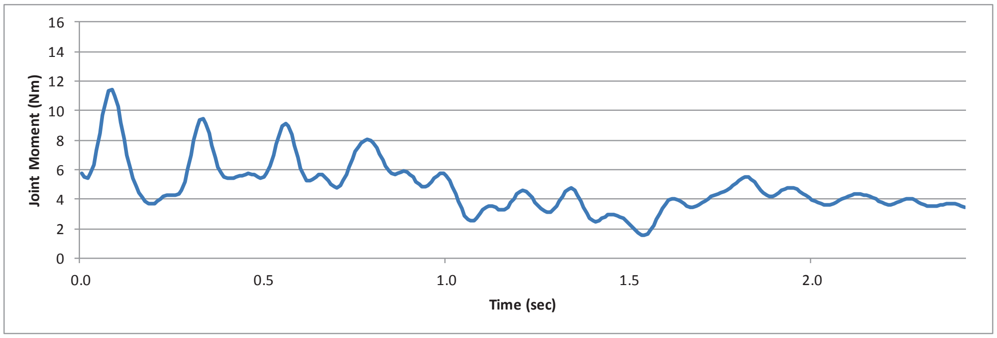
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	80.94	73.07	163.70
Tension (N)	NA	NA	NA
Anterior Shear (N)	24.76	8.24	5.61
Posterior Shear (N)	-40.13	-14.23	-22.19
Right Lateral Shear (N)	26.05	9.22	9.33
Left Lateral Shear (N)	-36.30	-10.75	-13.21
Torque (Resultant) (Nm)	10.58	5.67	12.70
Right Lateral Moment (+Mx) (Nm	3.53	1.71	1.60
Left Lateral Moment (-Mx) (Nm)	-4.14	-1.56	-2.03
Left Axial Moment (+My) (Nm)	1.92	0.58	0.68
Right Axial Moment (-My) (Nm)	-1.72	-0.46	-0.49
Extension Moment (+Mz) (Nm)	8.54	4.43	9.90
Flexion Moment (-Mz) (Nm)	-1.20	-0.75	-0.03

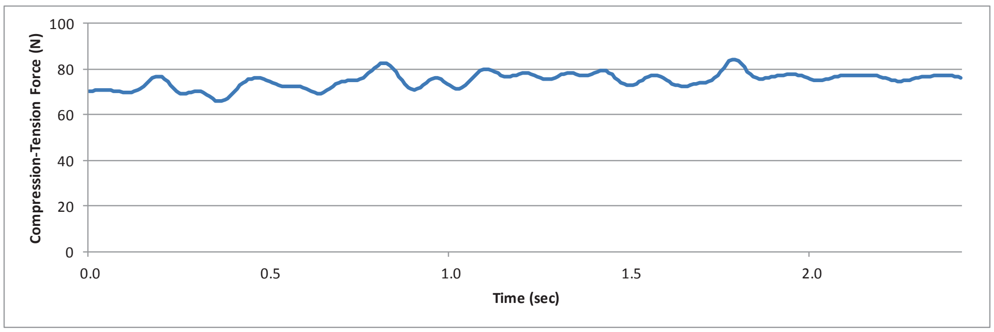
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	8.90	5.88
Left Lateral Bend	-8.81	-6.97
Left Axial Rotation	24.45	13.66
Right Axial Rotation	-13.44	-11.20
Extension	NA	NA
Flexion	-20.54	-15.66

Door Opening Outside - Night

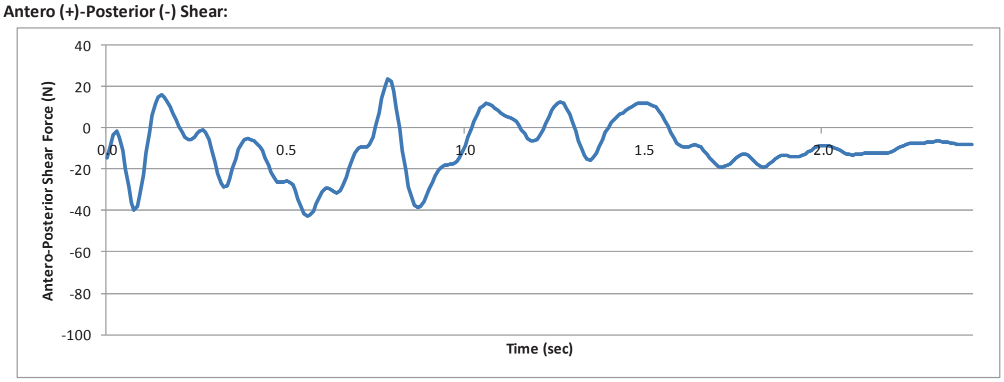
Resultant Neck Torque:



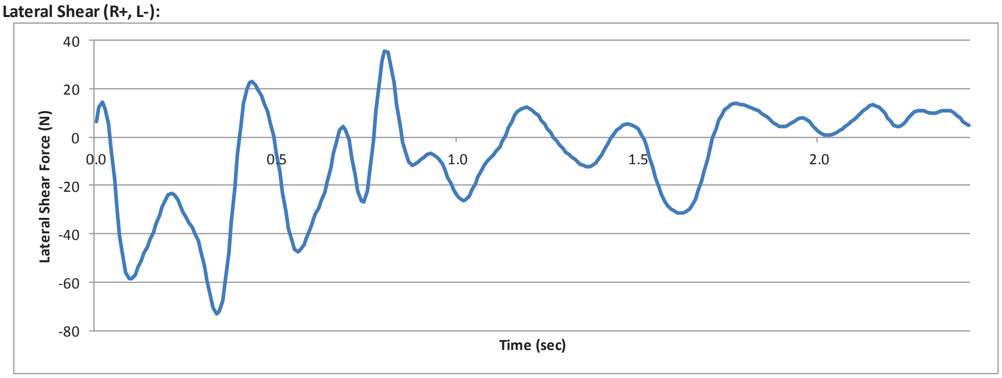
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



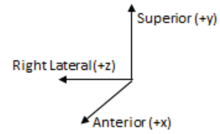
Lateral Shear (R+, L-):



Equipment Handling Inside – Day

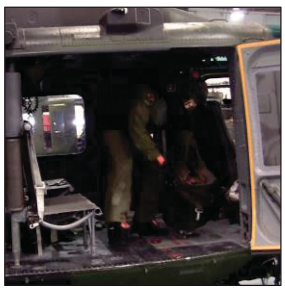
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Equipment Handling Inside (FE)
DAY	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet Only



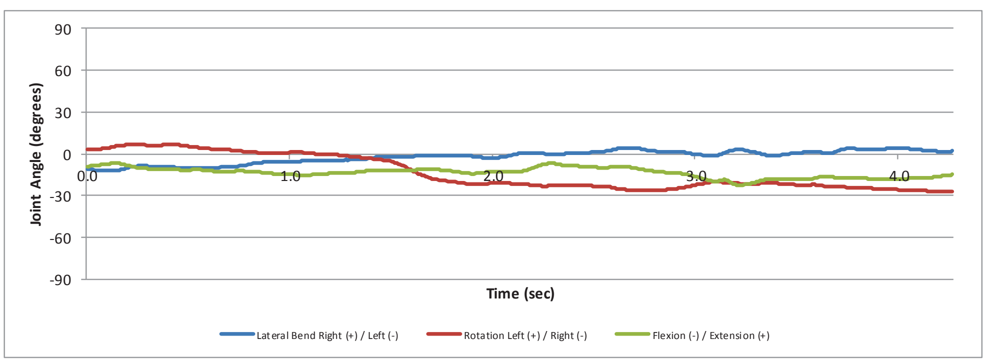
Task Description:	Equipment Considerations:
FE stands, stooped over, inside the cabin on the NFP side and moves equipment and gear inside the AC to the FP side.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Sling Bag (17 kg)

Image:


Photograph


MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	2.914	seconds

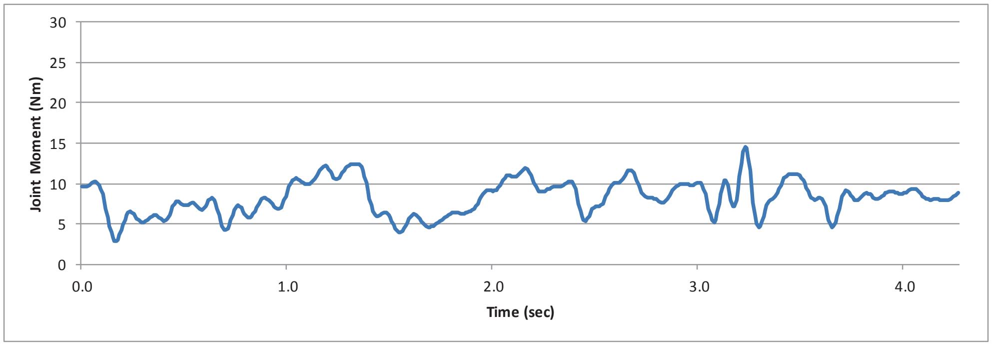
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	52.78	27.05	78.57
Tension (N)	-7.68	-2.65	-0.29
Anterior Shear (N)	26.22	17.33	2.34
Posterior Shear (N)	-93.19	-47.05	-132.21
Right Lateral Shear (N)	38.19	13.48	14.15
Left Lateral Shear (N)	-41.81	-18.79	-35.18
Torque (Resultant) (Nm)	15.00	8.50	24.83
Right Lateral Moment (+Mx) (Nm)	4.79	1.66	1.58
Left Lateral Moment (-Mx) (Nm)	-5.92	-2.54	-5.00
Left Axial Moment (+My) (Nm)	2.06	1.07	1.63
Right Axial Moment (-My) (Nm)	-2.55	-1.36	-1.91
Extension Moment (+Mz) (Nm)	12.92	6.96	20.09
Flexion Moment (-Mz) (Nm)	-2.45	-2.63	-0.13

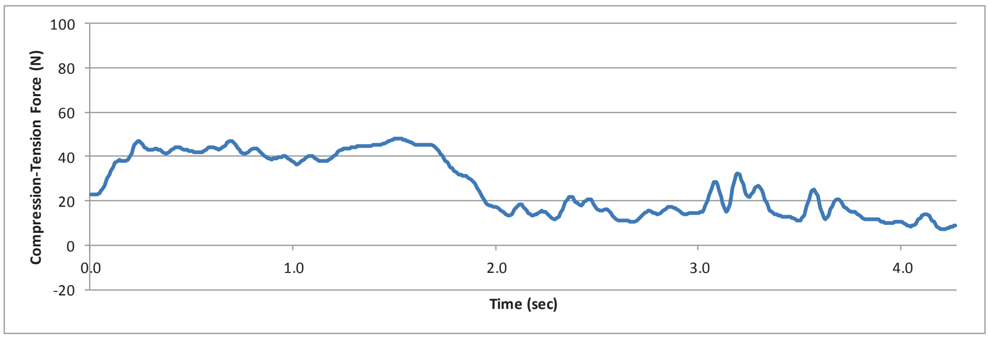
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	10.17	8.56
Left Lateral Bend	-9.99	-6.18
Left Axial Rotation	6.50	3.61
Right Axial Rotation	-36.17	-25.15
Extension	2.22	1.95
Flexion	-18.89	-11.32

Equipment Handling Inside – Day

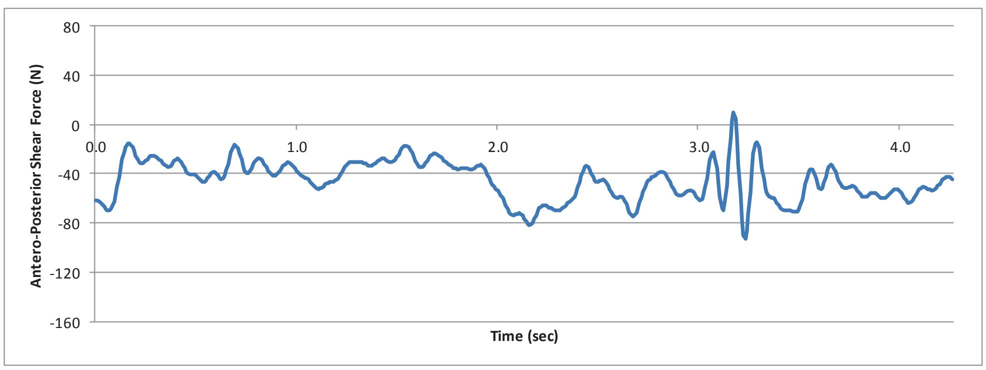
Resultant Neck Torque:



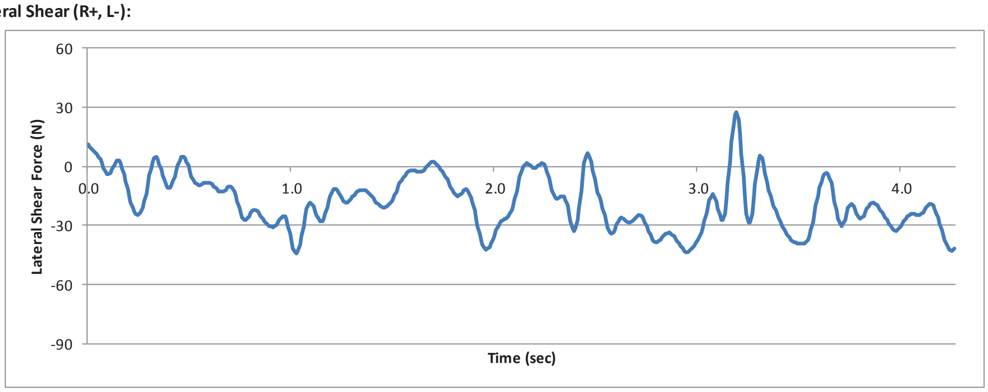
Compression(+)-Tension(-):



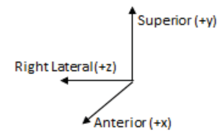
Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):



Equipment Handling Inside – Night



Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Equipment Handling Inside (FE)
NIGHT	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG

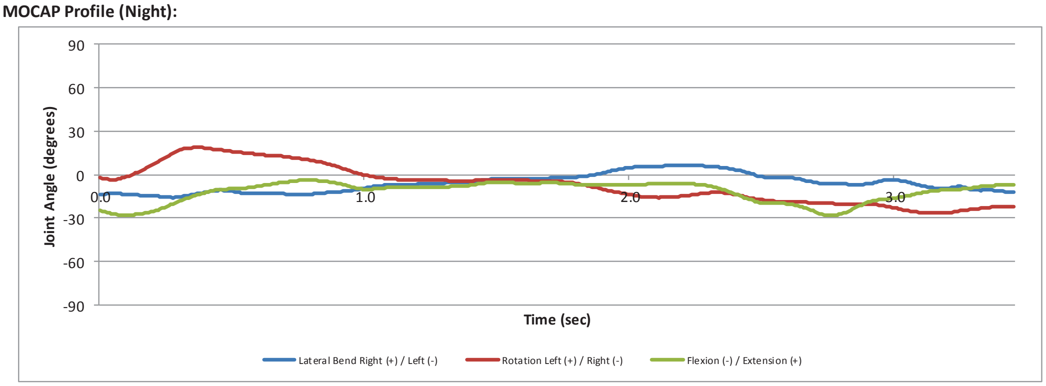
Task Description:	Equipment Considerations:
FE stands, stooped over, inside the cabin on the NFP side and moves equipment and gear inside the AC to the FP side.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Sling Bag (17 kg)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Night):



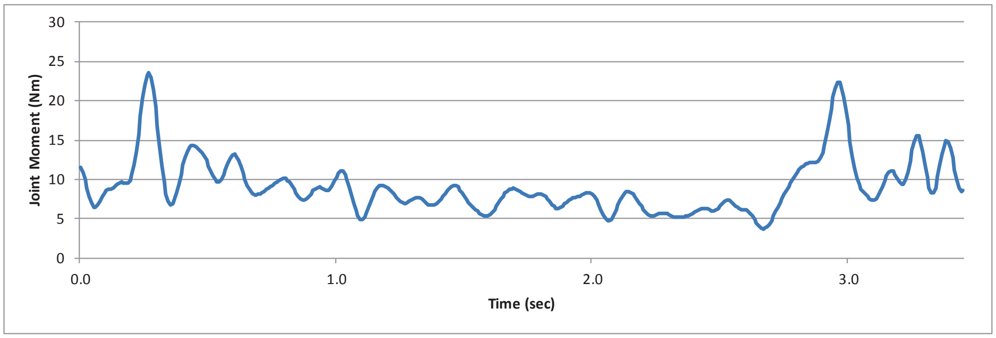
Posture Duration:	2.775	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

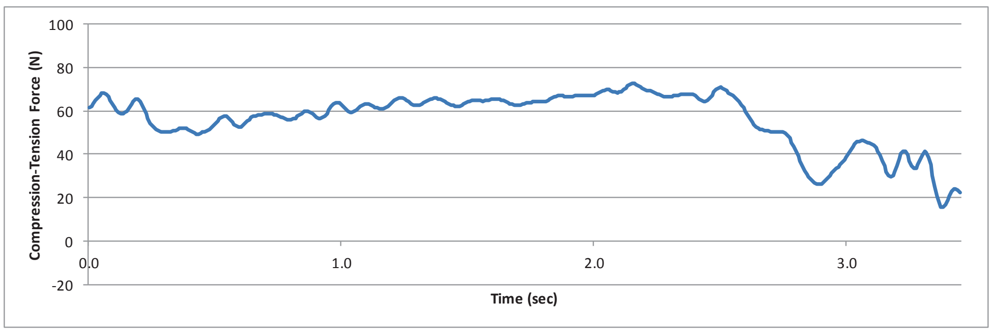
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	62.90	42.47	103.64	Right Lateral Bend	10.51	10.54
Tension (N)	-17.23	-7.81	-5.36	Left Lateral Bend	-12.28	-6.59
Anterior Shear (N)	28.88	15.55	2.36	Left Axial Rotation	14.06	11.53
Posterior Shear (N)	-124.40	-56.41	-149.88	Right Axial Rotation	-27.34	-17.13
Right Lateral Shear (N)	63.71	19.89	25.02	Extension	9.02	4.84
Left Lateral Shear (N)	-51.34	-20.10	-30.66	Flexion	-19.67	-14.70
Torque (Resultant) (Nm)	19.01	10.20	28.39			
Right Lateral Moment (+Mx) (Nm	8.14	2.74	2.93			
Left Lateral Moment (-Mx) (Nm)	-7.45	-2.88	-4.94			
Left Axial Moment (+My) (Nm)	3.28	1.26	1.88			
Right Axial Moment (-My) (Nm)	-3.28	-1.45	-1.88			
Extension Moment (+Mz) (Nm)	17.23	8.60	23.66			
Flexion Moment (-Mz) (Nm)	-1.54	-1.06	-0.06			

Equipment Handling Inside – Night

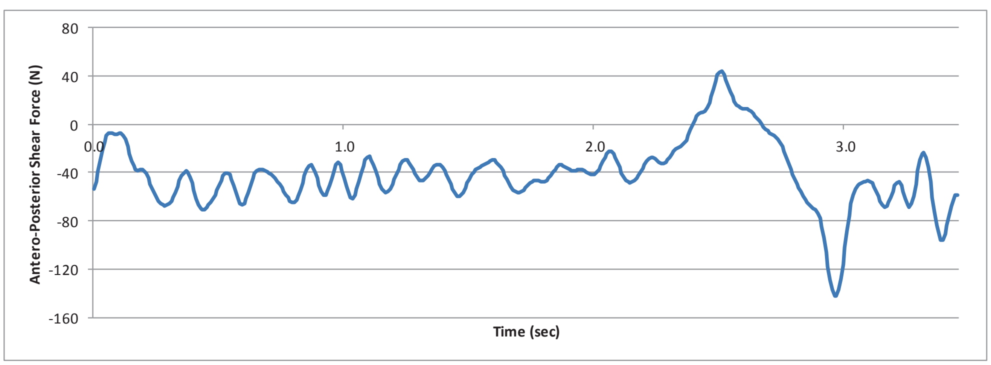
Resultant Neck Torque:



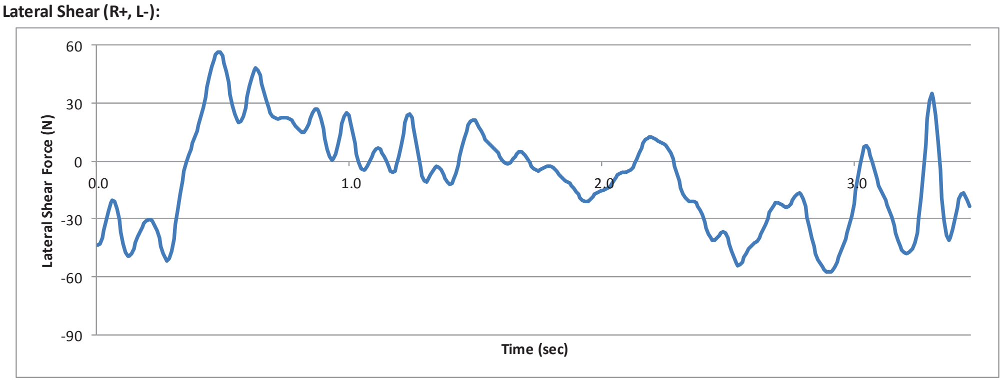
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



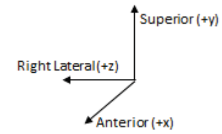
Lateral Shear (R+, L-):



Equipment Handling Outside – Day

Griffon MFTA - PDA: Postural Sequence

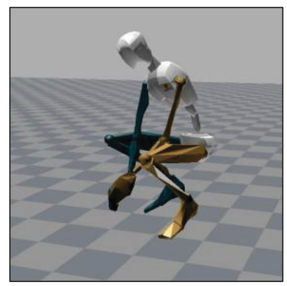
Postural Sequence:	Equipment Handling Outside (FE)
DAY	
Participant # (Sample Graphs):	FE03
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
Outside the AC on the FP side, the FE lifts and loads equipment into the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Sling Bag (17 kg)

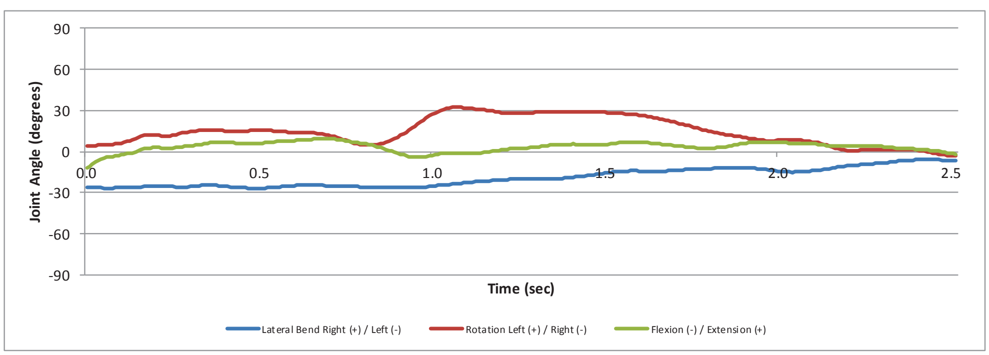
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	3.781	seconds

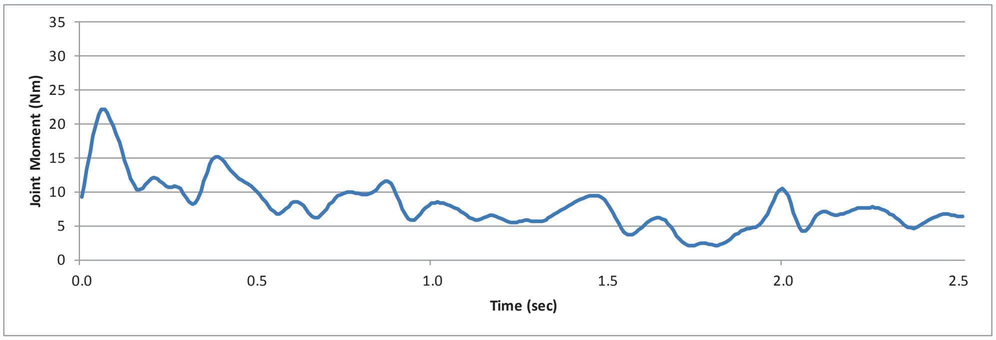
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	61.06	45.47	170.89
Tension (N)	-3.28	-1.77	-0.16
Anterior Shear (N)	19.73	7.87	1.88
Posterior Shear (N)	-99.07	-34.04	-120.83
Right Lateral Shear (N)	44.15	14.15	24.13
Left Lateral Shear (N)	-43.45	-12.07	-25.15
Torque (Resultant) (Nm)	16.97	6.97	26.42
Right Lateral Moment (+Mx) (Nm)	4.87	2.05	2.05
Left Lateral Moment (-Mx) (Nm)	-6.97	-2.17	-6.06
Left Axial Moment (+My) (Nm)	3.03	1.03	1.66
Right Axial Moment (-My) (Nm)	-2.71	-1.20	-2.61
Extension Moment (+Mz) (Nm)	13.55	5.59	20.79
Flexion Moment (-Mz) (Nm)	-1.51	-1.18	-0.12

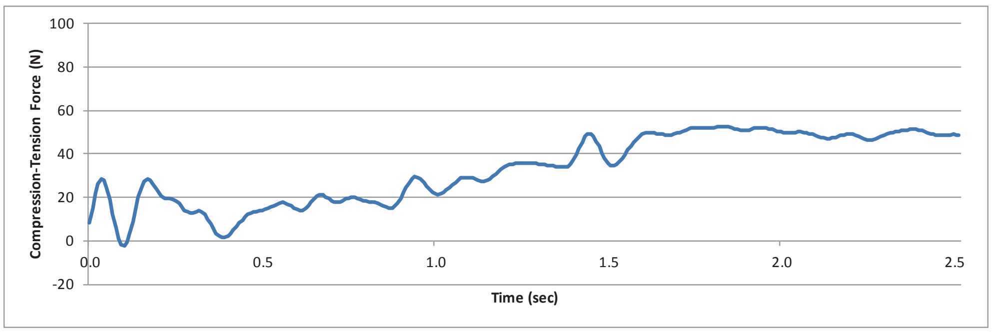
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	19.89	13.23
Left Lateral Bend	-11.79	-8.19
Left Axial Rotation	15.16	12.03
Right Axial Rotation	-35.58	-24.10
Extension	7.43	4.81
Flexion	-22.72	-13.52

Equipment Handling Outside – Day

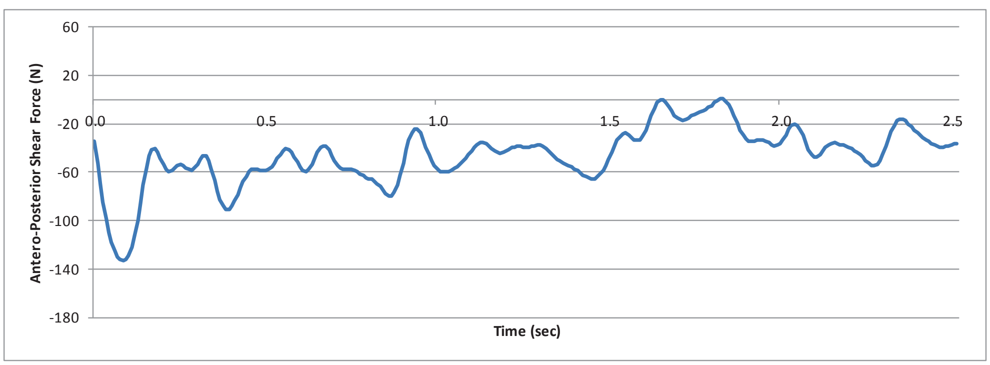
Resultant Neck Torque:



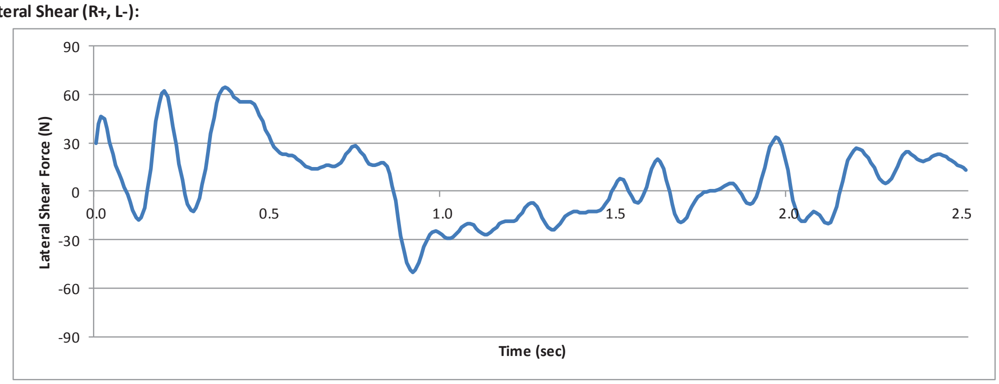
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



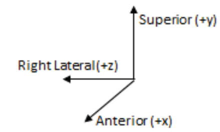
Lateral Shear (R+, L-):



Equipment Handling Outside - Night

Griffon MFTA - PDA: Postural Sequence

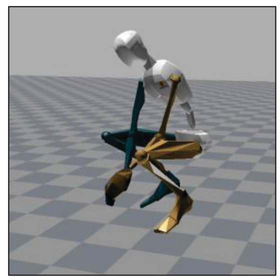
Postural Sequence:	Equipment Handling Outside (FE)
NIGHT	
Participant # (Sample Graphs):	FE03
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Outside the AC on the FP side, the FE lifts and loads equipment into the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Sling Bag (17 kg)

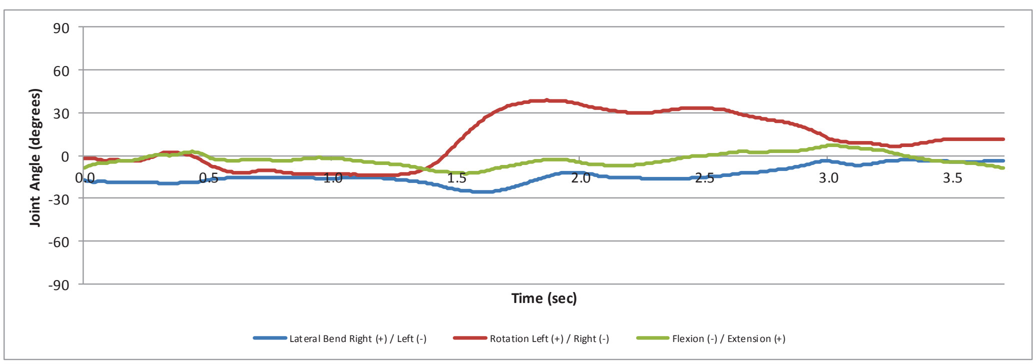
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	3.835	seconds

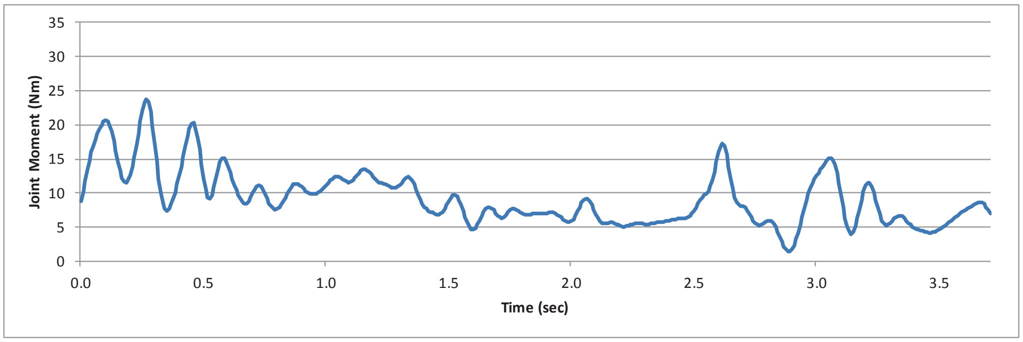
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	76.60	57.24	219.02
Tension (N)	-4.96	-5.20	-0.26
Anterior Shear (N)	25.88	10.04	2.26
Posterior Shear (N)	-114.15	-41.56	-150.37
Right Lateral Shear (N)	43.51	15.73	27.33
Left Lateral Shear (N)	-37.38	-13.91	-29.29
Torque (Resultant) (Nm)	23.09	8.95	34.40
Right Lateral Moment (+Mx) (Nm	5.25	2.20	3.35
Left Lateral Moment (-Mx) (Nm)	-5.38	-2.08	-4.83
Left Axial Moment (+My) (Nm)	3.06	1.24	2.64
Right Axial Moment (-My) (Nm)	-2.63	-1.27	-2.17
Extension Moment (+Mz) (Nm)	16.53	7.33	27.93
Flexion Moment (-Mz) (Nm)	-3.76	-2.63	-0.18

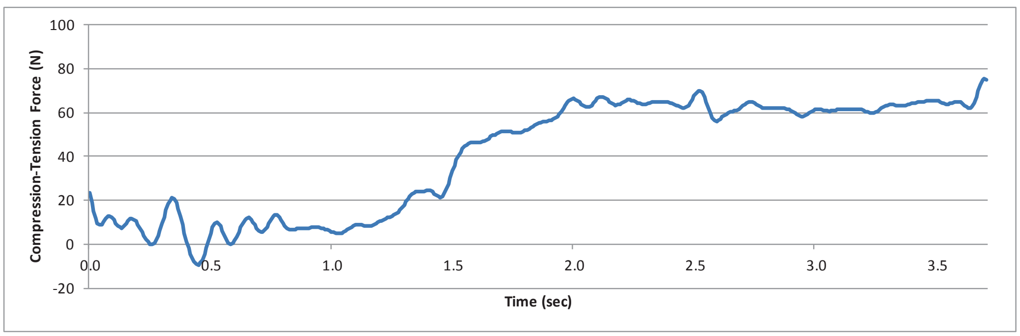
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	13.65	9.02
Left Lateral Bend	-13.94	-8.30
Left Axial Rotation	18.02	14.40
Right Axial Rotation	-20.79	-11.27
Extension	6.42	3.12
Flexion	-23.46	-12.78

Equipment Handling Outside - Night

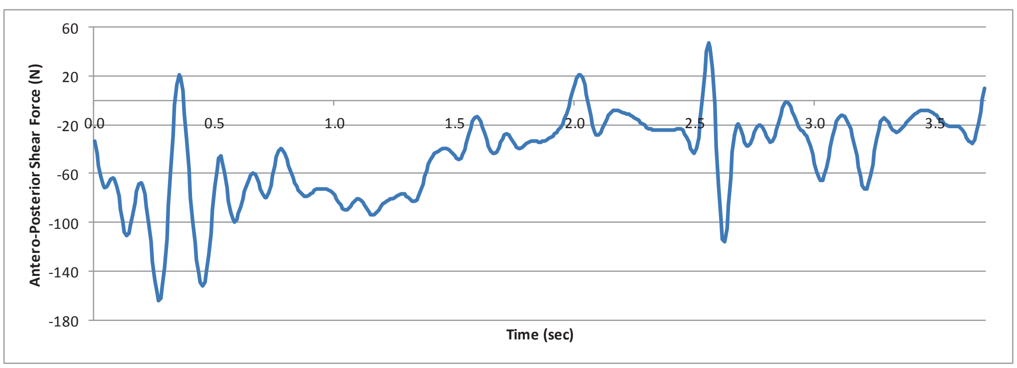
Resultant Neck Torque:



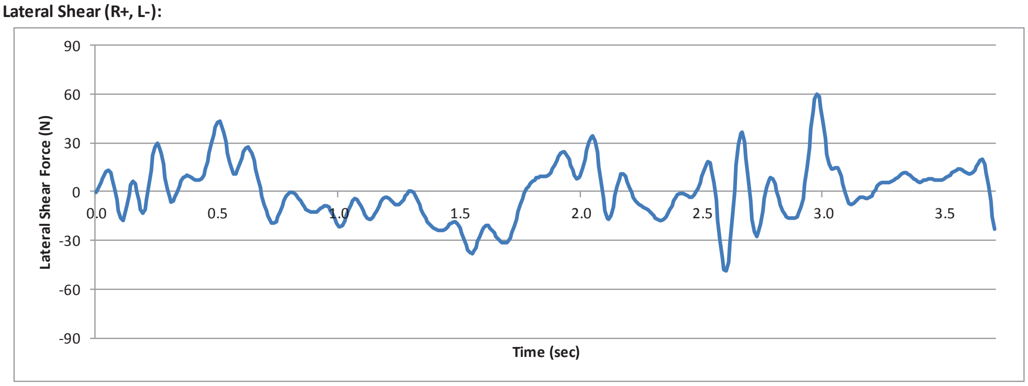
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



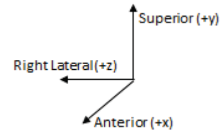
Lateral Shear (R+, L-):



Ingress - Day

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Ingress (FE)
DAY	
Participant # (Sample Graphs)	FE02
Role:	Flight Engineer
Helmet Condition:	Helmet Only



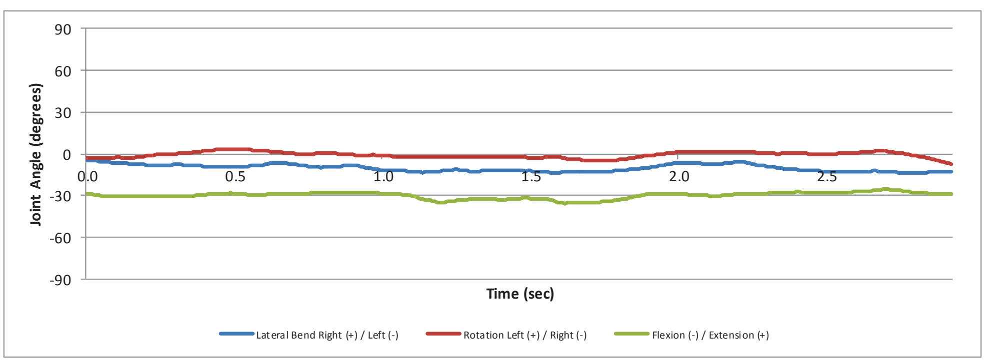
Task Description:	**Equipment Considerations:**
Outside the AC with the door open, the FE steps up into the cabin and sits in the jump seat facing forward.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	3.419	seconds

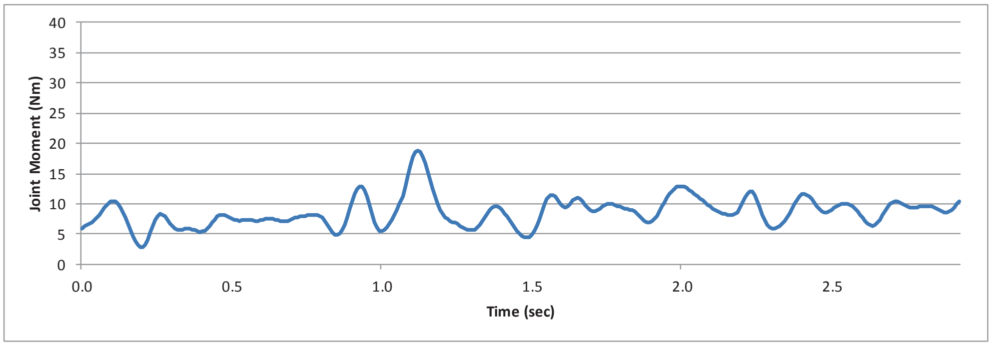
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	71.97	43.82	150.20
Tension (N)	NA	NA	NA
Anterior Shear (N)	68.69	18.97	15.25
Posterior Shear (N)	-91.61	-39.32	-103.16
Right Lateral Shear (N)	63.62	21.05	51.33
Left Lateral Shear (N)	-51.02	-12.81	-12.67
Torque (Resultant) (Nm)	17.66	7.53	25.80
Right Lateral Moment (+Mx) (Nm)	7.80	2.83	6.57
Left Lateral Moment (-Mx) (Nm)	-5.79	-1.53	-1.69
Left Axial Moment (+My) (Nm)	3.73	1.05	1.32
Right Axial Moment (-My) (Nm)	-4.03	-1.35	-2.93
Extension Moment (+Mz) (Nm)	13.54	6.14	20.12
Flexion Moment (-Mz) (Nm)	-4.29	-2.50	-0.37

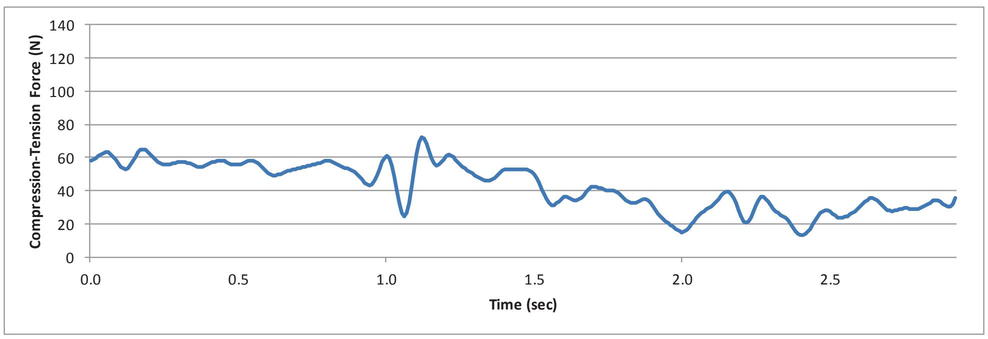
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	5.91	9.04
Left Lateral Bend	-11.38	-6.14
Left Axial Rotation	9.98	6.17
Right Axial Rotation	-14.83	-8.24
Extension	0.85	0.55
Flexion	-34.14	-22.88

Ingress – Day

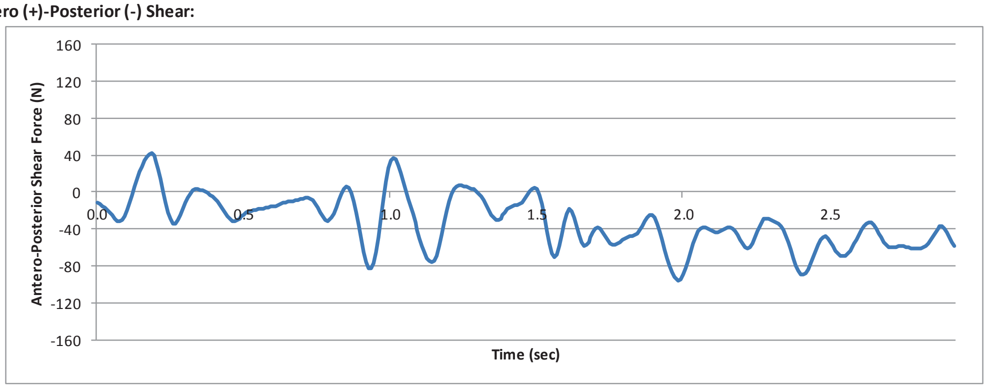
Resultant Neck Torque:



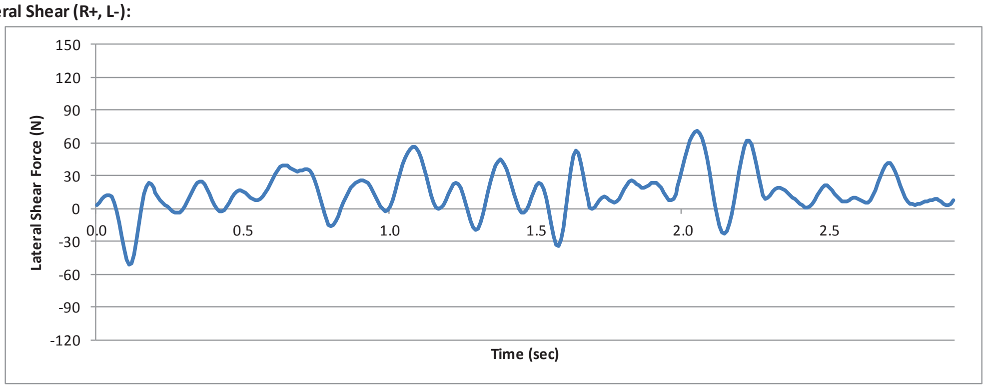
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



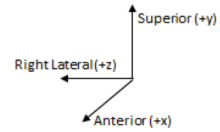
Lateral Shear (R+, L-):



Ingress – Night

Griffon MFTA - PDA: Postural Sequence

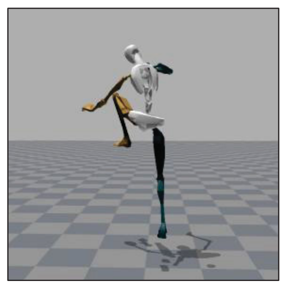
Postural Sequence:	Ingress (FE)
NIGHT	
Participant # (Sample Graphs)	FE02
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
Outside the AC with the door open, the FE steps up into the cabin and sits in the jump seat facing forward.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

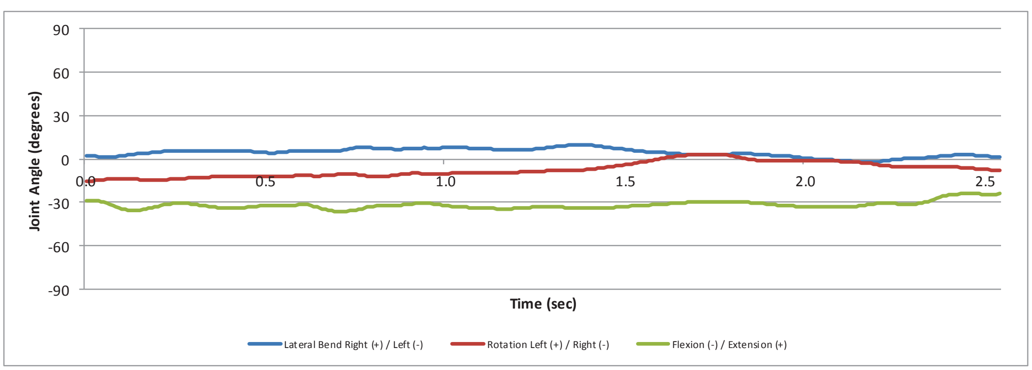
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



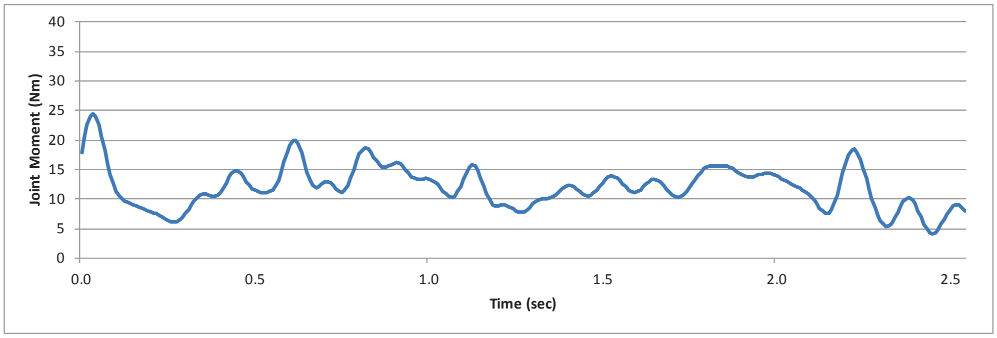
Posture Duration:	4.028	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

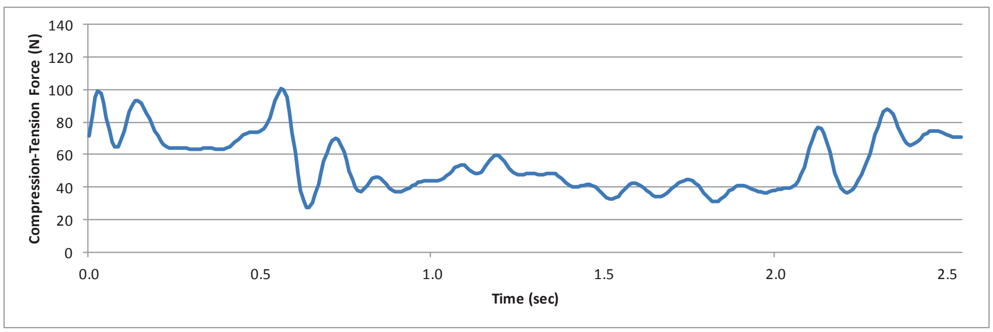
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	94.65	59.93	241.89	Right Lateral Bend	13.59	8.00
Tension (N)	NA	NA	NA	Left Lateral Bend	-11.57	-7.85
Anterior Shear (N)	89.48	19.42	17.83	Left Axial Rotation	17.33	9.06
Posterior Shear (N)	-113.90	-42.09	-131.25	Right Axial Rotation	-12.95	-6.89
Right Lateral Shear (N)	84.43	23.48	67.43	Extension	NA	NA
Left Lateral Shear (N)	-69.82	-16.17	-18.82	Flexion	-33.42	-23.06
Torque (Resultant) (Nm)	21.52	9.33	37.64			
Right Lateral Moment (+Mx) (Nm	10.20	3.12	7.70			
Left Lateral Moment (-Mx) (Nm)	-8.24	-1.79	-2.81			
Left Axial Moment (+My) (Nm)	4.52	1.19	1.47			
Right Axial Moment (-My) (Nm)	-6.28	-1.76	-4.93			
Extension Moment (+Mz) (Nm)	17.63	7.64	29.67			
Flexion Moment (-Mz) (Nm)	-8.56	-4.29	-0.79			

Ingress – Night

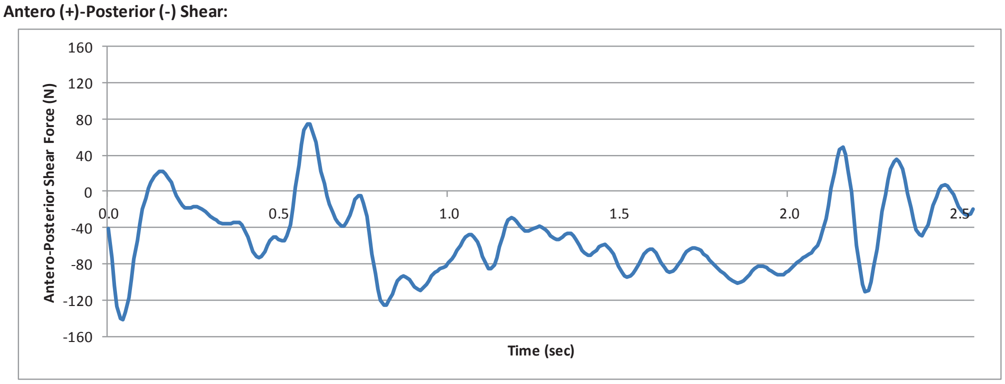
Resultant Neck Torque:



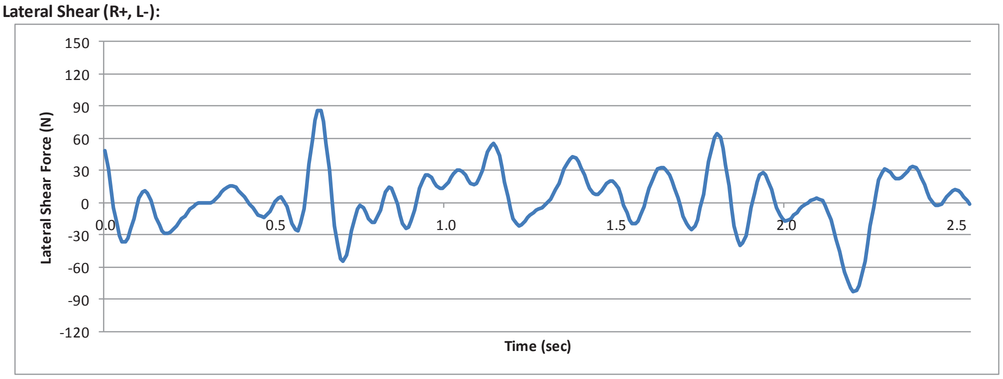
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



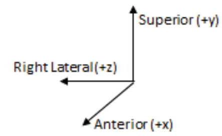
Lateral Shear (R+, L-):



Scan Confined – Day

Griffon MFTA - PDA: Postural Sequence

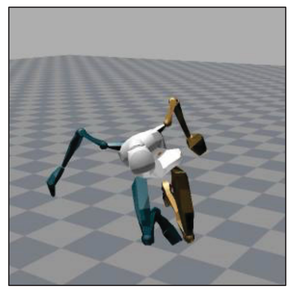
Postural Sequence:	Scan Confined (FE)
DAY	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
Kneeling in the door frame, the FE scans forward, side, back, and down. In a confined area the FE must scan more frequently and extend further out of the cabin to improve sight lines.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

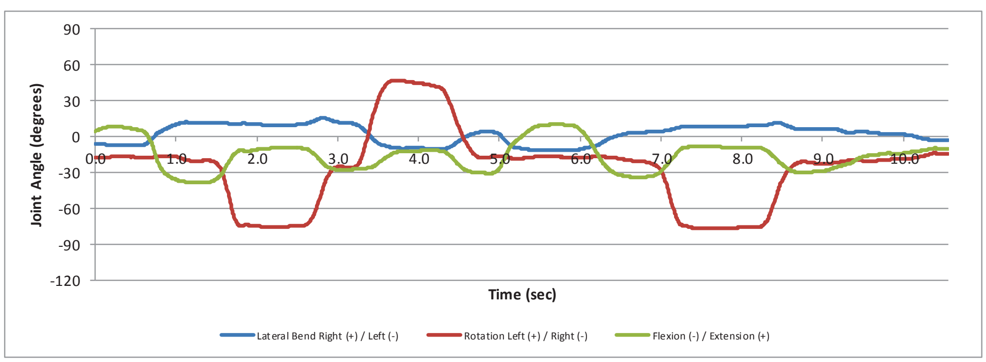
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	11.207	seconds

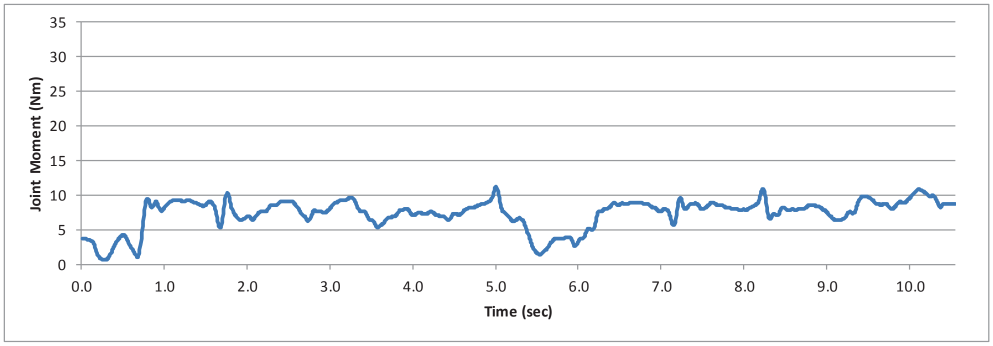
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	49.64	33.60	372.96
Tension (N)	-8.79	-2.95	-2.04
Anterior Shear (N)	24.16	18.92	1.58
Posterior Shear (N)	-72.37	-44.82	-501.42
Right Lateral Shear (N)	24.08	6.22	36.25
Left Lateral Shear (N)	-28.75	-18.08	-132.49
Torque (Resultant) (Nm)	17.01	7.41	83.16
Right Lateral Moment (+Mx) (Nm)	2.68	0.71	1.97
Left Lateral Moment (-Mx) (Nm)	-4.52	-1.90	-16.01
Left Axial Moment (+My) (Nm)	2.67	1.43	8.65
Right Axial Moment (-My) (Nm)	-1.81	-1.21	-6.24
Extension Moment (+Mz) (Nm)	11.27	6.47	72.46
Flexion Moment (-Mz) (Nm)	-6.53	-2.68	-0.36

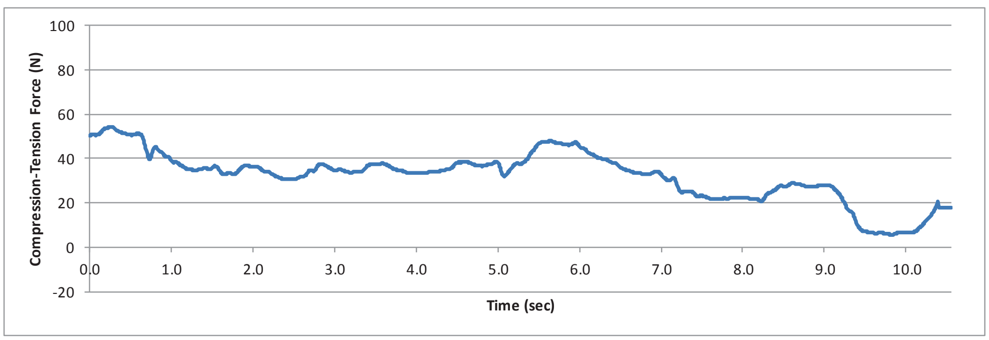
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	10.35	8.98
Left Lateral Bend	-17.39	-11.11
Left Axial Rotation	36.80	23.81
Right Axial Rotation	-77.71	-43.97
Extension	14.10	7.84
Flexion	-33.36	-13.45

Scan Confined – Day

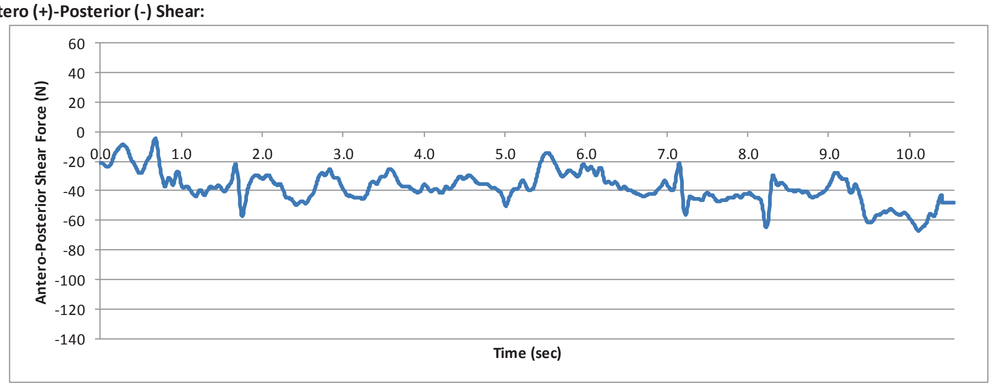
Resultant Neck Torque:



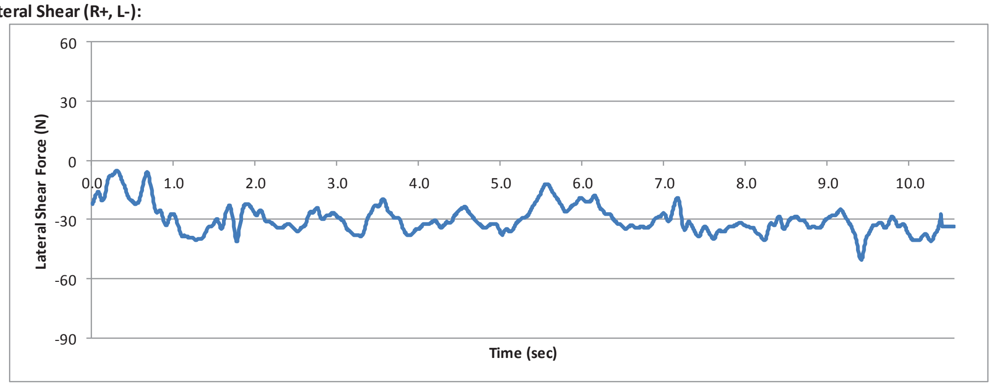
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



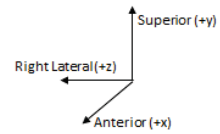
Lateral Shear (R+, L-):



Scan Confined – Night

Griffon MFTA - PDA: Postural Sequence

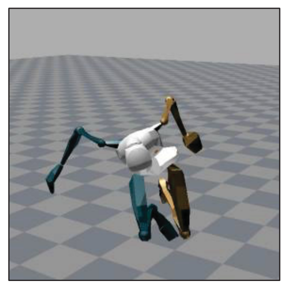
Postural Sequence:	Scan Confined (FE)
NIGHT	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Kneeling in the door frame, the FE scans forward, side, back, and down. In a confined area the FE must scan more frequently and extend further out of the cabin to improve sight lines.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

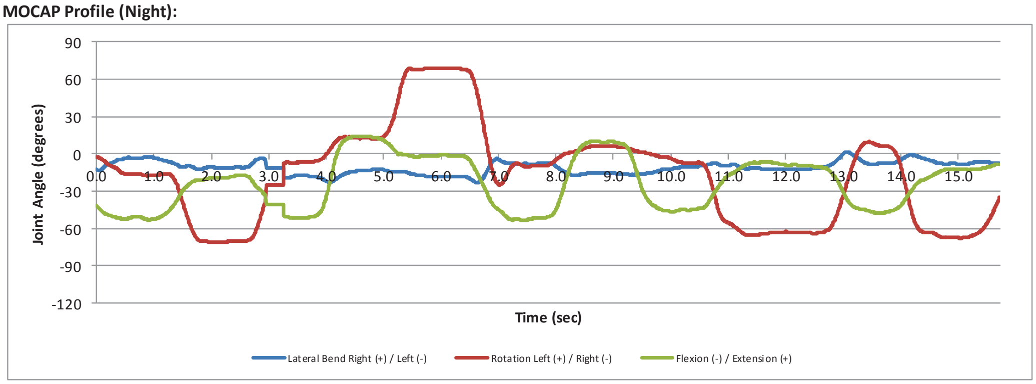
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



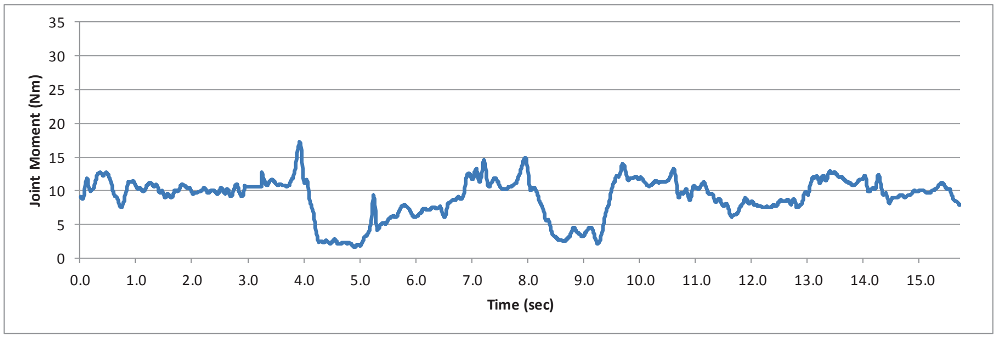
Posture Duration:	13.786	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

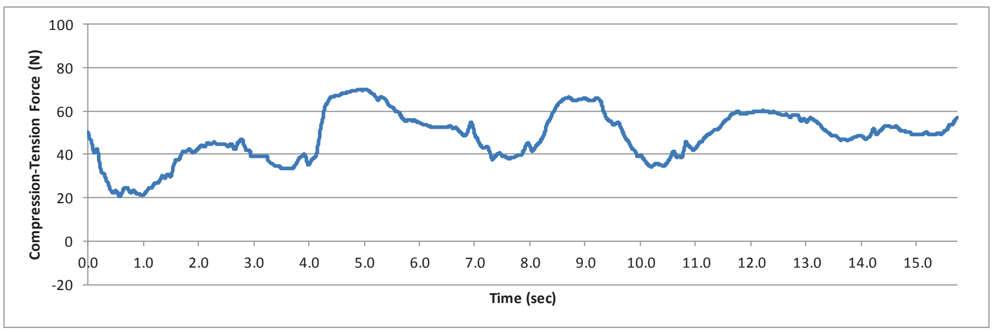
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	65.44	53.02	731.35	Right Lateral Bend	24.14	17.85
Tension (N)	NA	NA	NA	Left Lateral Bend	-13.47	-11.47
Anterior Shear (N)	NA	NA	NA	Left Axial Rotation	47.78	23.73
Posterior Shear (N)	-76.47	-45.74	-630.96	Right Axial Rotation	-81.47	-36.75
Right Lateral Shear (N)	23.57	9.46	144.68	Extension	12.30	9.88
Left Lateral Shear (N)	-33.03	-19.75	-171.79	Flexion	-51.49	-28.23
Torque (Resultant) (Nm)	20.57	8.44	116.38			
Right Lateral Moment (+Mx) (Nm	2.04	0.78	1.48			
Left Lateral Moment (-Mx) (Nm)	-6.66	-2.59	-31.64			
Left Axial Moment (+My) (Nm)	3.83	2.03	12.40			
Right Axial Moment (-My) (Nm)	-3.66	-2.58	-19.86			
Extension Moment (+Mz) (Nm)	13.08	7.07	97.52			
Flexion Moment (-Mz) (Nm)	NA	NA	NA			

Scan Confined – Night

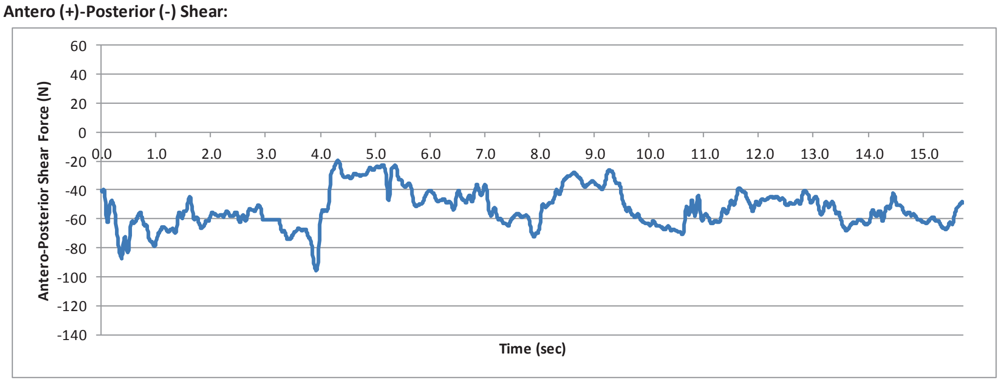
Resultant Neck Torque:



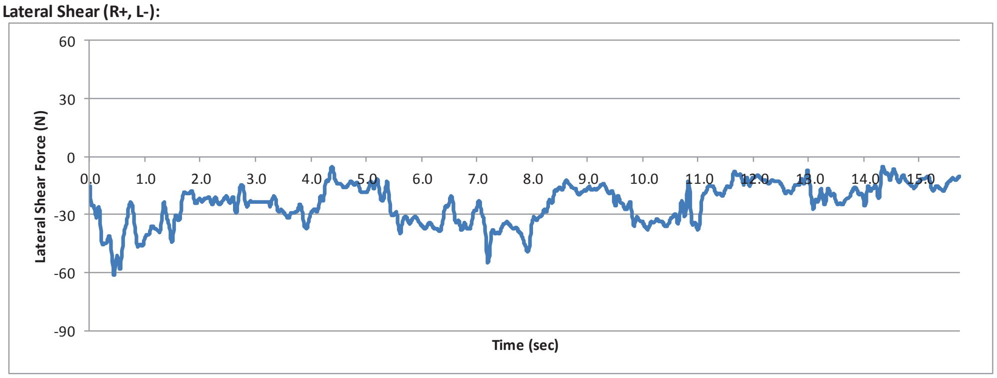
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



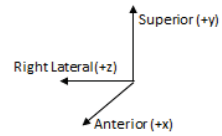
Lateral Shear (R+, L-):



Scan During Slide to Sling – Day

Griffon MFTA - PDA: Postural Sequence

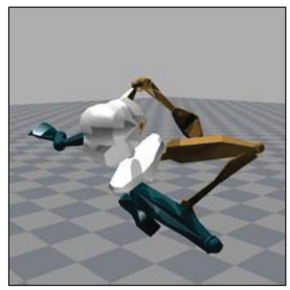
Postural Sequence:	Scan during Slide to Sling (FE)
DAY	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
FE extends out at cabin door to observe AC slide forward to load to sling. FE looks for peto clearance and wire strike clearance.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

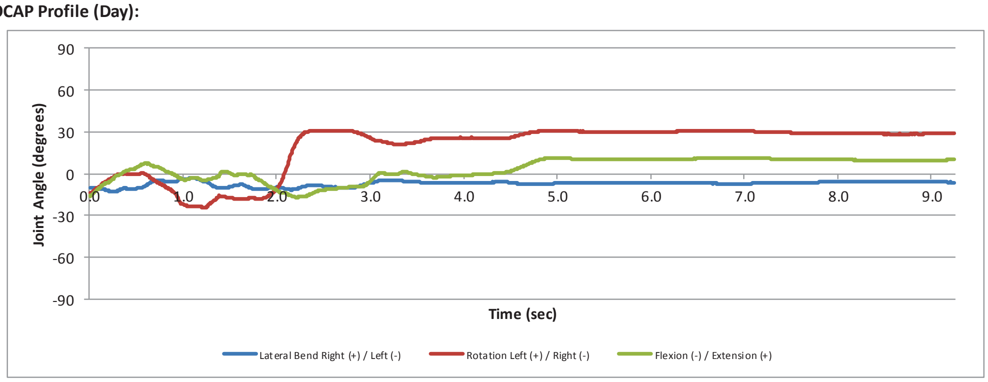
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	9.378	seconds

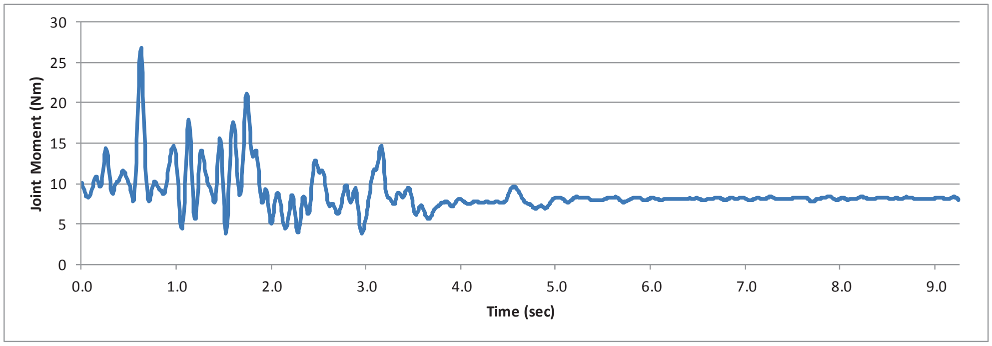
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	47.23	29.29	205.81
Tension (N)	-26.07	-19.48	-91.94
Anterior Shear (N)	19.73	13.54	1.05
Posterior Shear (N)	-72.76	-41.06	-383.84
Right Lateral Shear (N)	25.49	15.13	13.49
Left Lateral Shear (N)	-44.59	-26.11	-233.41
Torque (Resultant) (Nm)	12.81	7.59	71.21
Right Lateral Moment (+Mx) (Nm)	2.96	1.59	1.75
Left Lateral Moment (-Mx) (Nm)	-6.02	-3.65	-31.54
Left Axial Moment (+My) (Nm)	2.41	1.67	9.60
Right Axial Moment (-My) (Nm)	-2.15	-1.15	-8.35
Extension Moment (+Mz) (Nm)	10.58	6.00	56.23
Flexion Moment (-Mz) (Nm)	-4.39	-2.04	-0.27

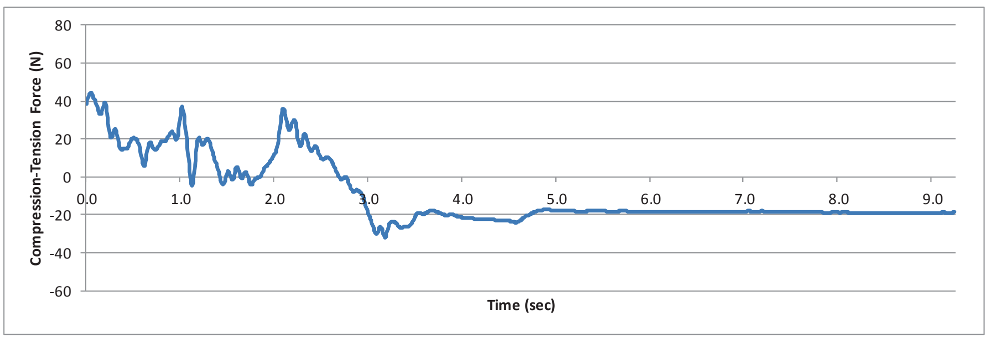
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	24.06	15.66
Left Lateral Bend	-11.20	-7.21
Left Axial Rotation	26.36	18.08
Right Axial Rotation	-21.93	-13.12
Extension	14.12	7.76
Flexion	-25.79	-12.73

Scan During Slide to Sling – Day

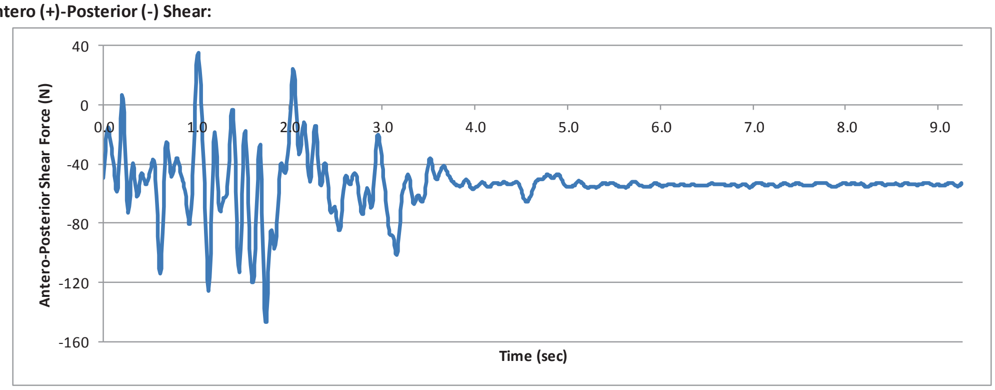
Resultant Neck Torque:



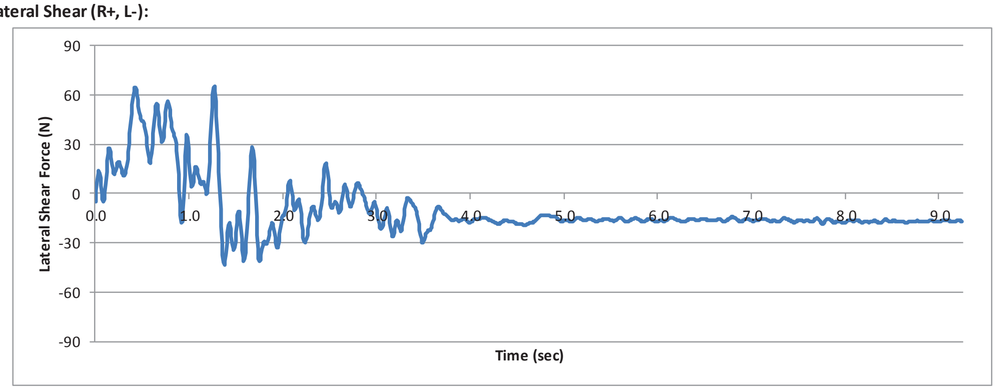
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



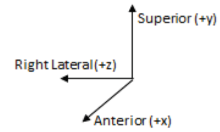
Lateral Shear (R+, L-):



Scan During Slide to Sling – Night

Griffon MFTA - PDA: Postural Sequence

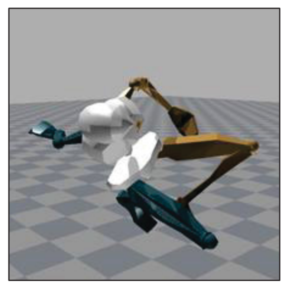
Postural Sequence:	Scan during Slide to Sling (FE)
NIGHT	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
FE extends out at cabin door to observe AC slide forward to load to sling. FE looks for peto clearance and wire strike clearance.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

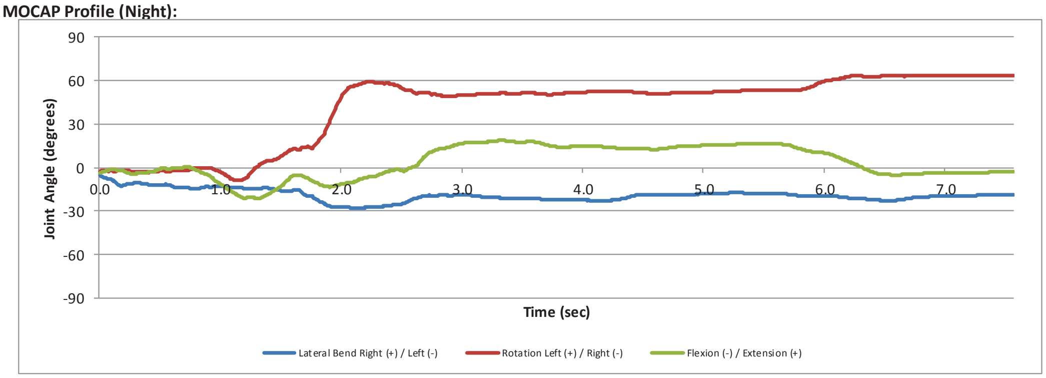
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	7.397	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	60.14	44.50	273.37	Right Lateral Bend	13.11	4.84
Tension (N)	-43.77	-34.63	-131.17	Left Lateral Bend	-15.15	-10.11
Anterior Shear (N)	10.25	7.56	0.36	Left Axial Rotation	50.97	40.03
Posterior Shear (N)	-92.46	-46.53	-343.51	Right Axial Rotation	-31.73	-19.57
Right Lateral Shear (N)	21.62	6.66	6.13	Extension	16.41	10.22
Left Lateral Shear (N)	-51.61	-29.54	-196.11	Flexion	-25.78	-17.41
Torque (Resultant) (Nm)	14.93	9.25	68.53			
Right Lateral Moment (+Mx) (Nm	3.94	1.70	2.70			
Left Lateral Moment (-Mx) (Nm)	-6.77	-4.01	-23.33			
Left Axial Moment (+My) (Nm)	5.48	2.53	17.85			
Right Axial Moment (-My) (Nm)	-1.62	-1.42	-0.58			
Extension Moment (+Mz) (Nm)	12.73	7.46	55.22			
Flexion Moment (-Mz) (Nm)	-0.24	-0.17	0.00			

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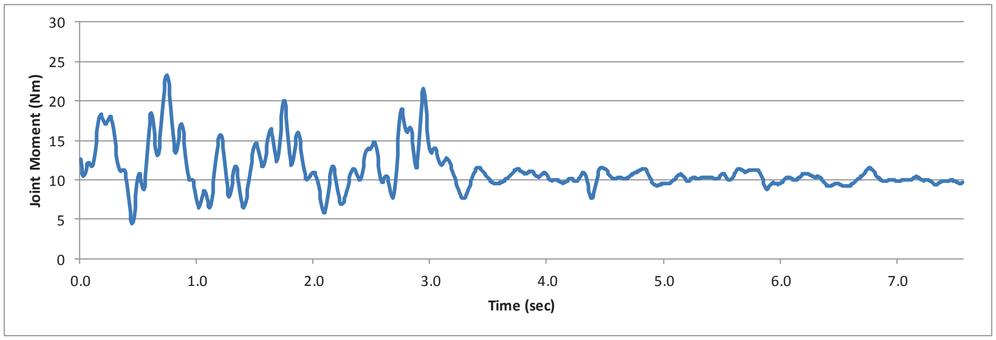
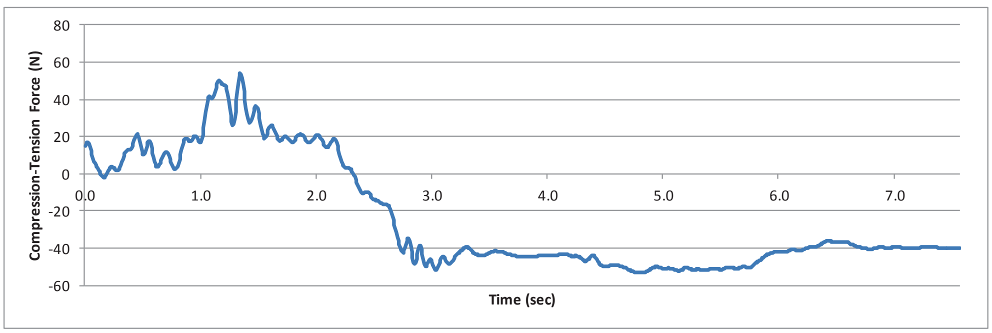
Scan During Slide to Sling – Night

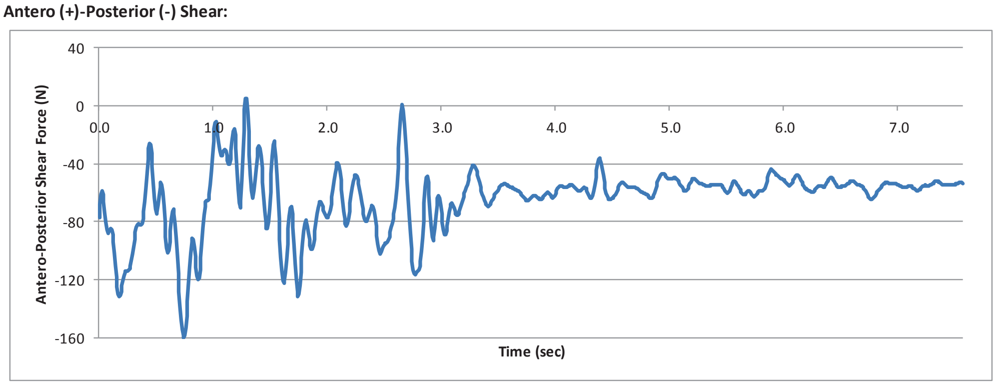
Resultant Neck Torque:



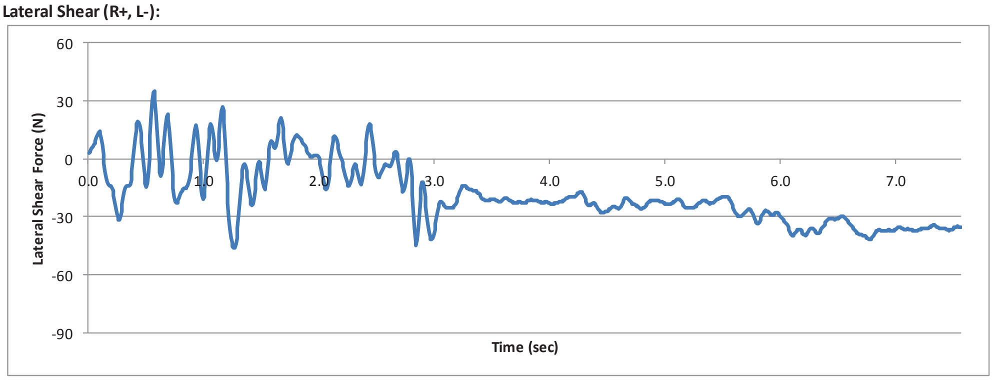
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



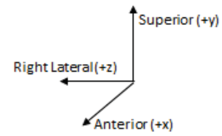
Lateral Shear (R+, L-):



Scan NFP Side – Day

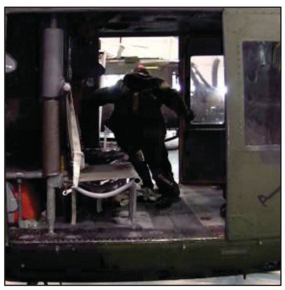
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Scan NFP Side (FE)
DAY	
Participant # (Sample Graphs):	FE02
Role:	Flight Engineer
Helmet Condition:	Helmet Only

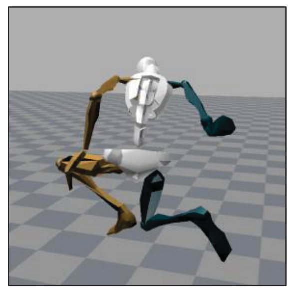


Task Description:	**Equipment Considerations:**
FE crosses over cabin, opens the door, and perform a regular scan on the NFP side.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

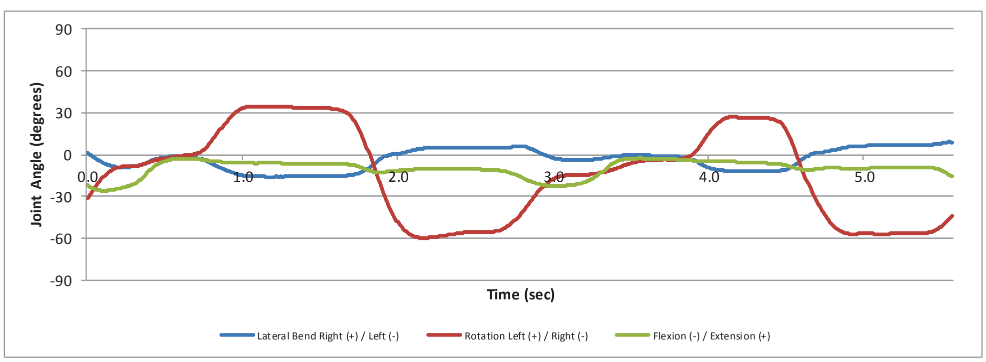


Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	9.897	seconds

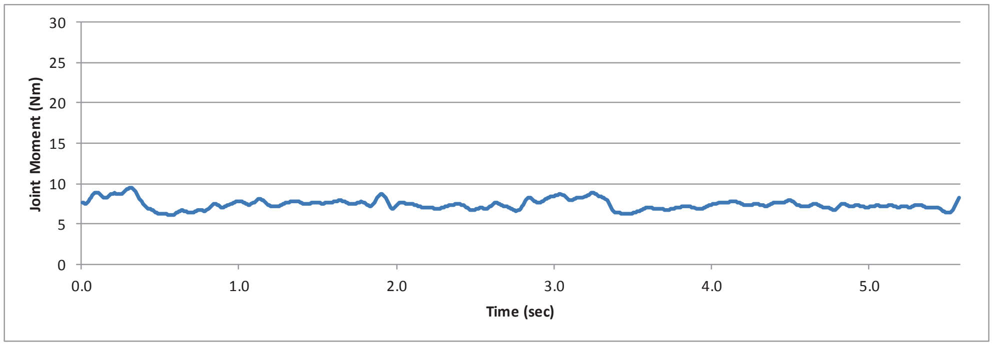
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	54.77	44.16	437.42
Tension (N)	NA	NA	NA
Anterior Shear (N)	28.44	16.62	2.28
Posterior Shear (N)	-59.78	-37.20	-366.82
Right Lateral Shear (N)	29.42	11.67	119.07
Left Lateral Shear (N)	-18.83	-10.02	-21.06
Torque (Resultant) (Nm)	12.22	6.53	64.66
Right Lateral Moment (+Mx) (Nm)	3.66	1.53	9.66
Left Lateral Moment (-Mx) (Nm)	-2.39	-0.72	-3.10
Left Axial Moment (+My) (Nm)	1.66	0.94	2.94
Right Axial Moment (-My) (Nm)	-2.48	-1.24	-8.40
Extension Moment (+Mz) (Nm)	10.03	6.01	59.52
Flexion Moment (-Mz) (Nm)	-2.15	-1.56	-0.07

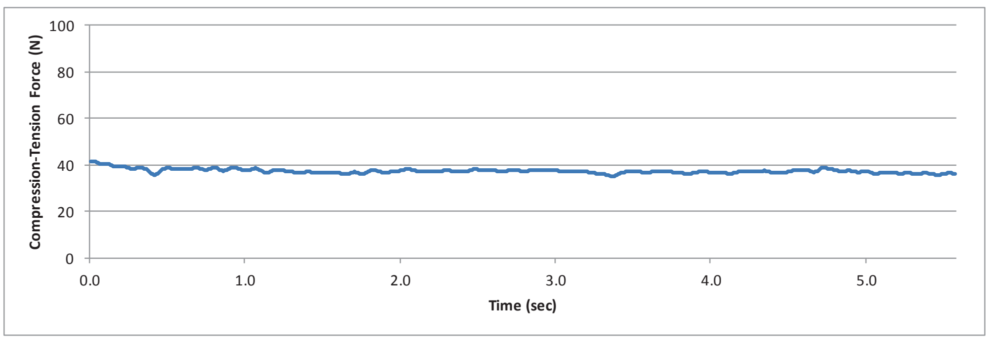
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	14.28	10.69
Left Lateral Bend	-11.89	-8.40
Left Axial Rotation	48.69	31.54
Right Axial Rotation	-61.20	-28.30
Extension	12.67	9.87
Flexion	-28.21	-16.11

Scan NFP Side - Day

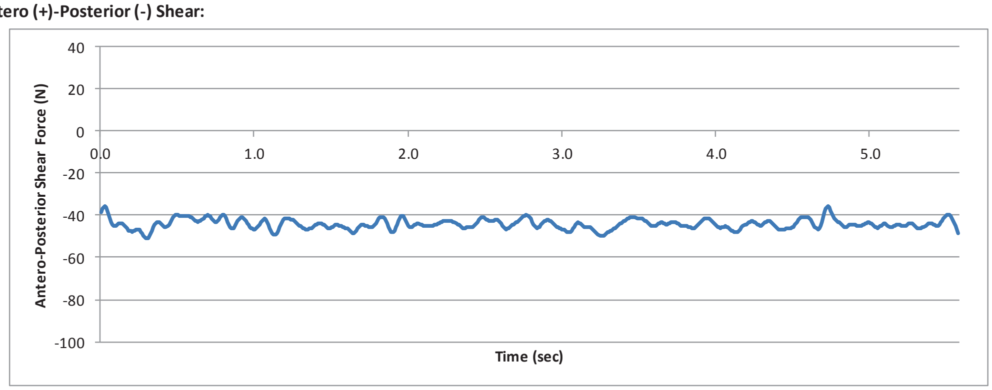
Resultant Neck Torque:



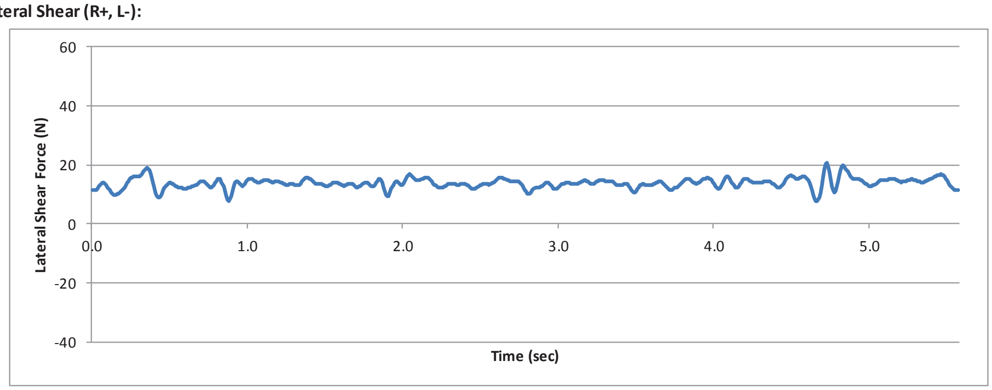
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



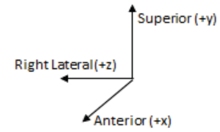
Lateral Shear (R+, L-):



Scan NFP Side – Night

Griffon MFTA - PDA: Postural Sequence

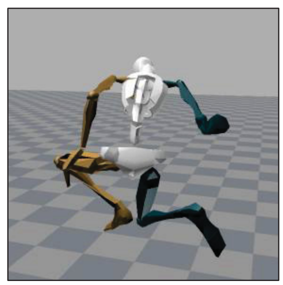
Postural Sequence:	Scan NFP Side (FE)
NIGHT	
Participant # (Sample Graphs):	FE02
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
FE crosses over cabin, opens the door, and perform a regular scan on the NFP side.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

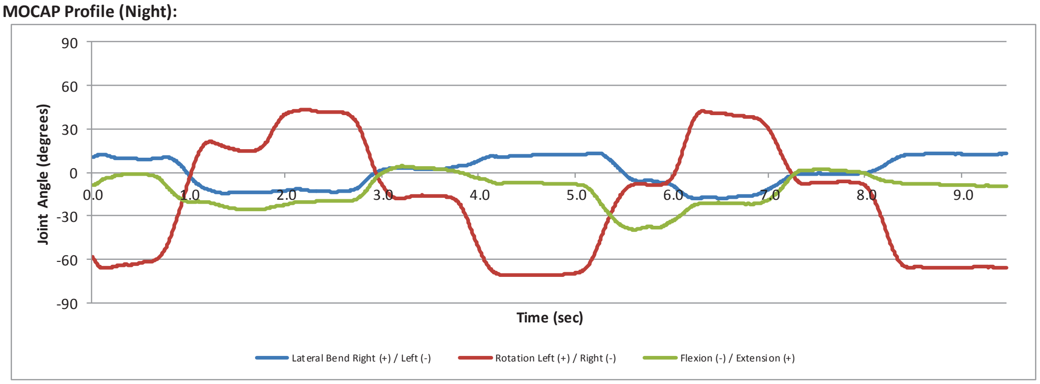
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



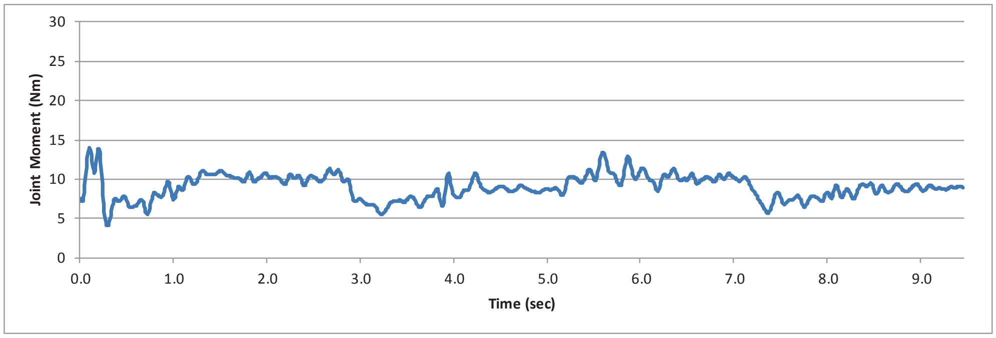
Posture Duration:	6.935	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

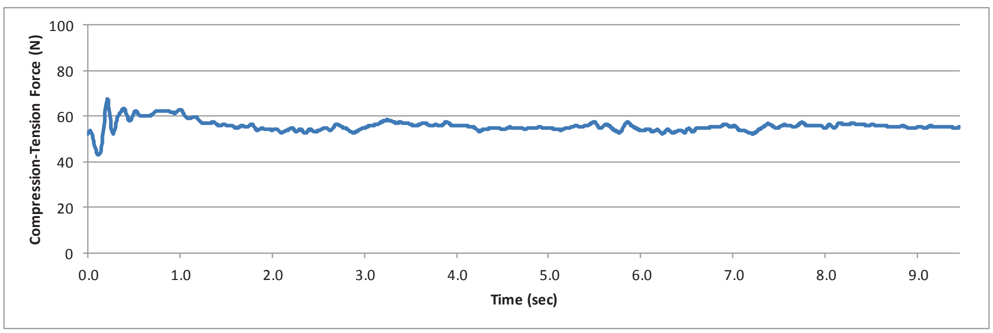
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	70.55	58.88	408.85	Right Lateral Bend	22.69	18.65
Tension (N)	NA	NA	NA	Left Lateral Bend	-20.21	-14.11
Anterior Shear (N)	8.98	6.41	0.85	Left Axial Rotation	60.40	36.94
Posterior Shear (N)	-69.41	-44.81	-308.71	Right Axial Rotation	-62.48	-44.82
Right Lateral Shear (N)	30.26	12.73	55.76	Extension	8.24	4.03
Left Lateral Shear (N)	-19.93	-9.58	-30.67	Flexion	-42.45	-19.07
Torque (Resultant) (Nm)	13.34	8.17	47.28			
Right Lateral Moment (+Mx) (Nm	4.98	1.88	10.06			
Left Lateral Moment (-Mx) (Nm)	-3.13	-1.77	-4.71			
Left Axial Moment (+My) (Nm)	3.57	2.03	9.23			
Right Axial Moment (-My) (Nm)	-3.73	-1.89	-7.83			
Extension Moment (+Mz) (Nm)	11.37	7.19	49.91			
Flexion Moment (-Mz) (Nm)	NA	NA	NA			

Scan NFP Side - Night

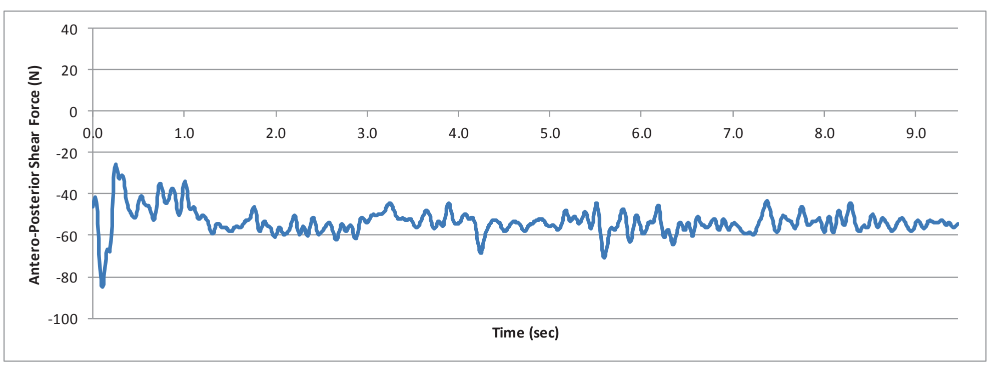
Resultant Neck Torque:



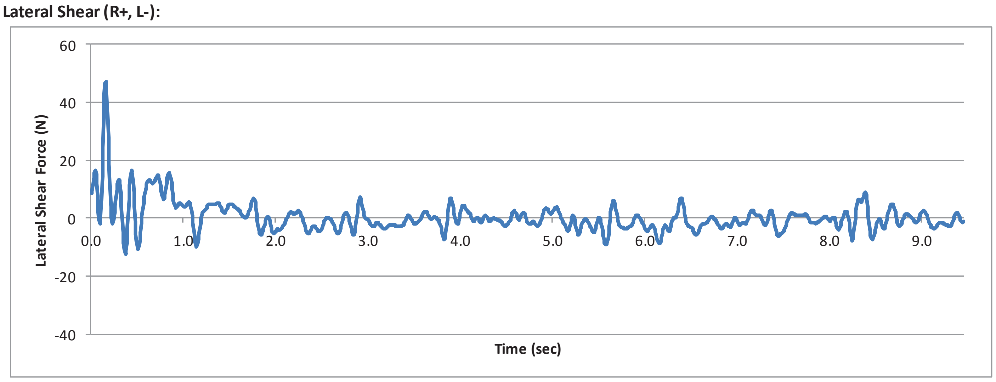
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



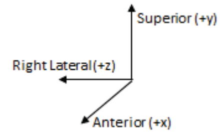
Lateral Shear (R+, L-):



Scan Regular Landing – Day

Griffon MFTA - PDA: Postural Sequence

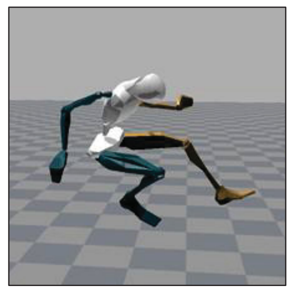
Postural Sequence:	Scan Regular Landing (FE)
DAY	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
Kneeling in the door frame, the FE scans forward, side, back, and down.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

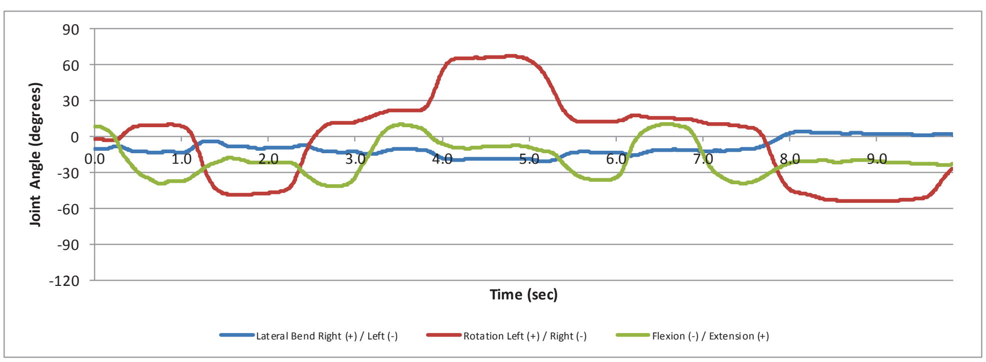
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	7.848	seconds

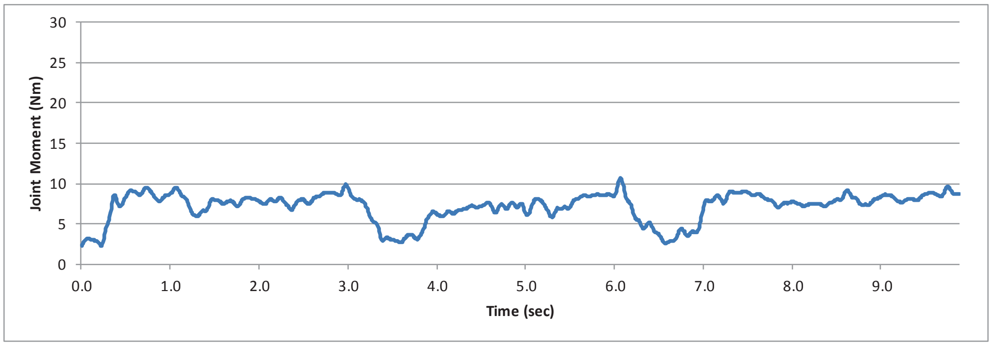
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	52.53	45.78	359.64
Tension (N)	NA	NA	NA
Anterior Shear (N)	NA	NA	NA
Posterior Shear (N)	-48.02	-34.74	-272.96
Right Lateral Shear (N)	11.96	10.13	22.87
Left Lateral Shear (N)	-22.66	-11.31	-91.93
Torque (Resultant) (Nm)	10.75	6.95	45.52
Right Lateral Moment (+Mx) (Nm)	1.82	0.74	3.32
Left Lateral Moment (-Mx) (Nm)	-3.88	-2.36	-12.16
Left Axial Moment (+My) (Nm)	1.53	1.13	4.49
Right Axial Moment (-My) (Nm)	-1.93	-1.24	-4.82
Extension Moment (+Mz) (Nm)	8.97	6.06	47.62
Flexion Moment (-Mz) (Nm)	NA	NA	NA

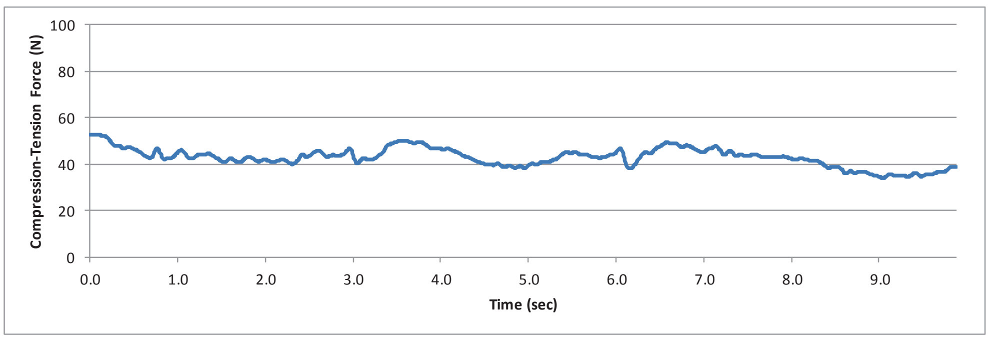
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	15.57	12.33
Left Lateral Bend	-14.89	-9.76
Left Axial Rotation	40.07	25.93
Right Axial Rotation	-73.06	-45.48
Extension	4.07	3.90
Flexion	-36.58	-16.79

Scan Regular Landing – Day

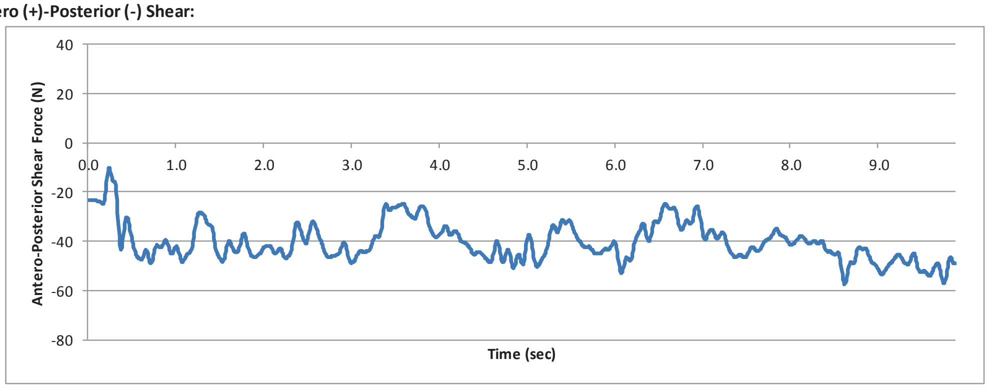
Resultant Neck Torque:



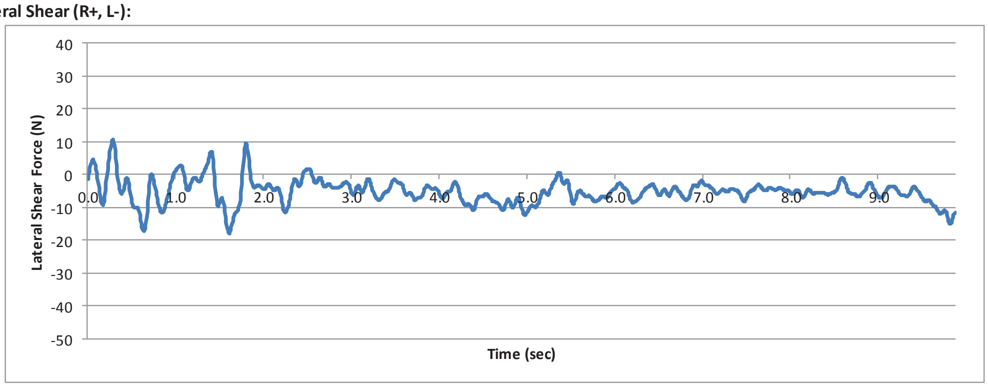
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



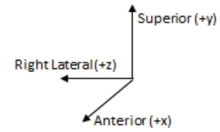
Lateral Shear (R+, L-):



Scan Regular Landing – Night

Griffon MFTA - PDA: Postural Sequence

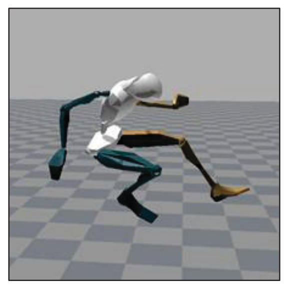
Postural Sequence:	Scan Regular Landing (FE)
NIGHT	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Kneeling in the door frame, the FE scans forward, side, back, and down.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

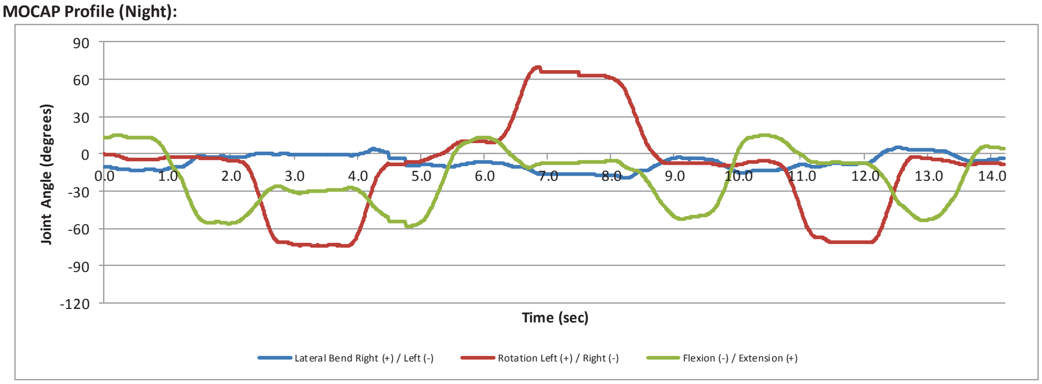
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	9.038	seconds

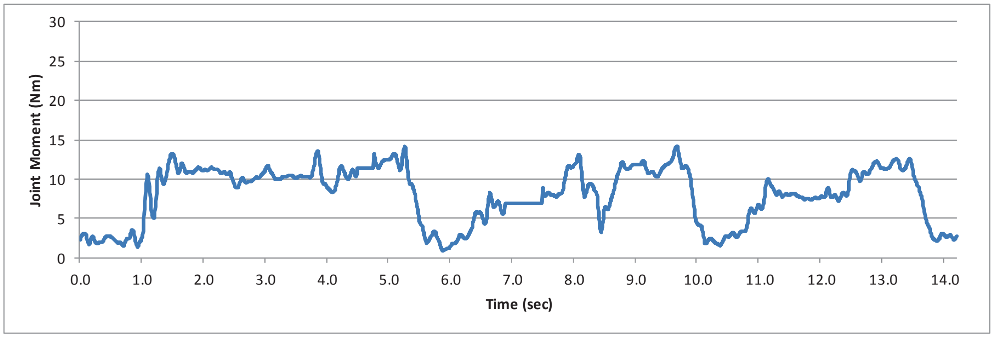
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	67.59	58.42	528.48
Tension (N)	NA	NA	NA
Anterior Shear (N)	NA	NA	NA
Posterior Shear (N)	-65.54	-42.06	-380.50
Right Lateral Shear (N)	13.31	7.39	16.72
Left Lateral Shear (N)	-26.81	-14.27	-107.55
Torque (Resultant) (Nm)	21.51	8.38	75.82
Right Lateral Moment (+Mx) (Nm	2.56	1.09	2.81
Left Lateral Moment (-Mx) (Nm)	-6.03	-2.75	-18.96
Left Axial Moment (+My) (Nm)	3.07	1.49	7.74
Right Axial Moment (-My) (Nm)	-3.88	-2.31	-8.90
Extension Moment (+Mz) (Nm)	12.50	7.01	63.17
Flexion Moment (-Mz) (Nm)	-0.93	-0.51	-0.11

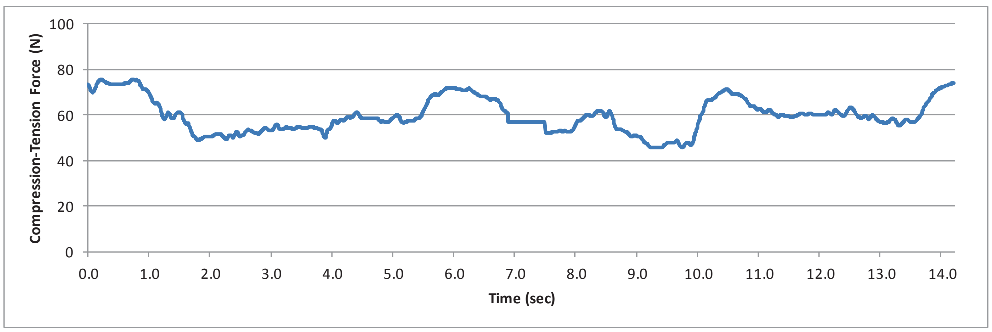
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	27.08	16.76
Left Lateral Bend	-15.02	-8.49
Left Axial Rotation	55.78	34.07
Right Axial Rotation	-82.57	-39.02
Extension	11.31	8.25
Flexion	-48.25	-22.30

Scan Regular Landing – Night

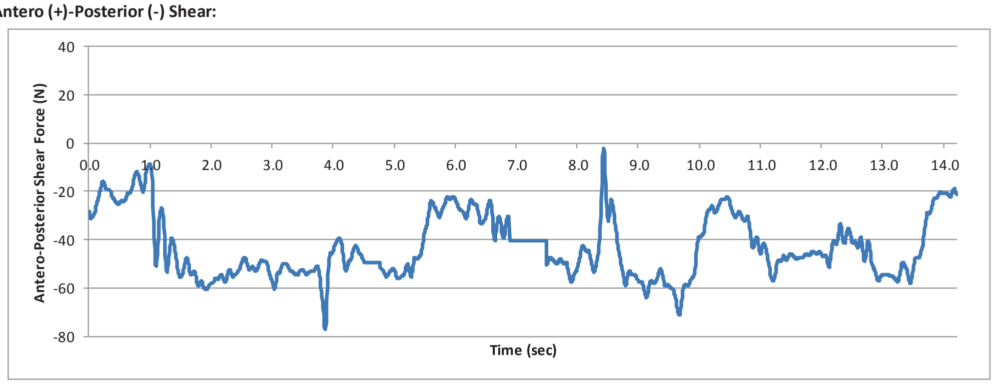
Resultant Neck Torque:



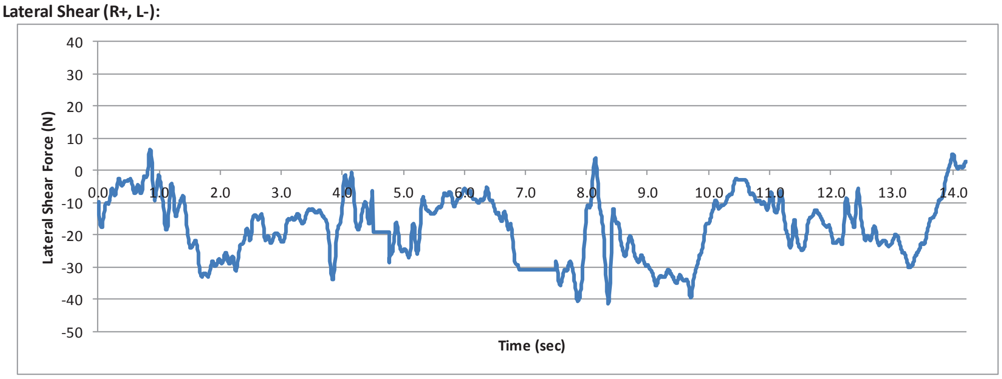
Compression(+)-Tension(-):



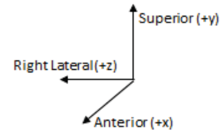
Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):



Scan Regular Take-off – Day



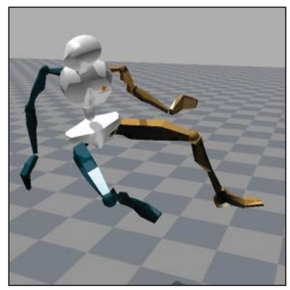
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Scan Regular Take-off (FE)
DAY	
Participant # (Sample Graphs):	FE03
Role:	Flight Engineer
Helmet Condition:	Helmet Only

Task Description:	**Equipment Considerations:**
Kneeling in the door frame, the FE scans forward, side, back, and up.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

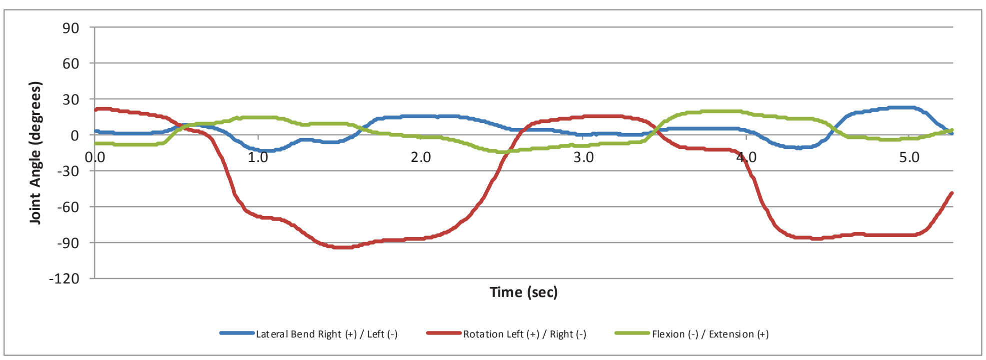
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	7.026	seconds

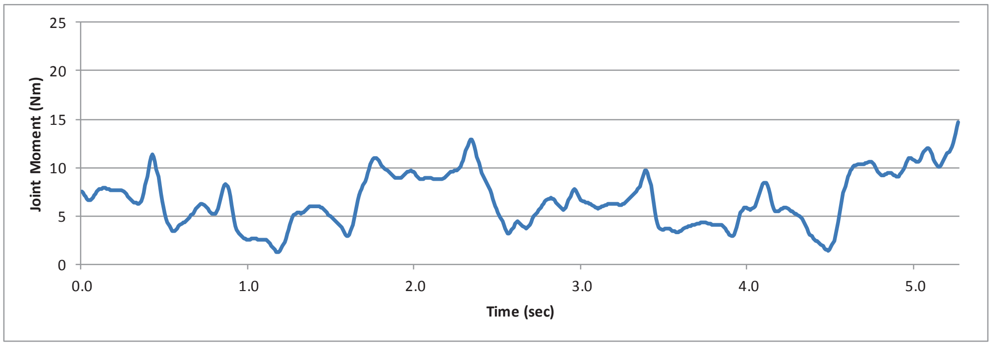
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	54.18	46.75	328.90
Tension (N)	NA	NA	NA
Anterior Shear (N)	6.57	3.91	0.16
Posterior Shear (N)	-52.35	-32.51	-228.48
Right Lateral Shear (N)	12.59	7.44	24.61
Left Lateral Shear (N)	-22.84	-11.66	-67.58
Torque (Resultant) (Nm)	12.77	6.24	43.91
Right Lateral Moment (+Mx) (Nm)	1.84	1.19	2.69
Left Lateral Moment (-Mx) (Nm)	-4.06	-1.75	-8.38
Left Axial Moment (+My) (Nm)	1.51	0.62	2.33
Right Axial Moment (-My) (Nm)	-1.74	-0.76	-2.51
Extension Moment (+Mz) (Nm)	9.20	5.68	37.27
Flexion Moment (-Mz) (Nm)	-2.56	-1.53	-1.44

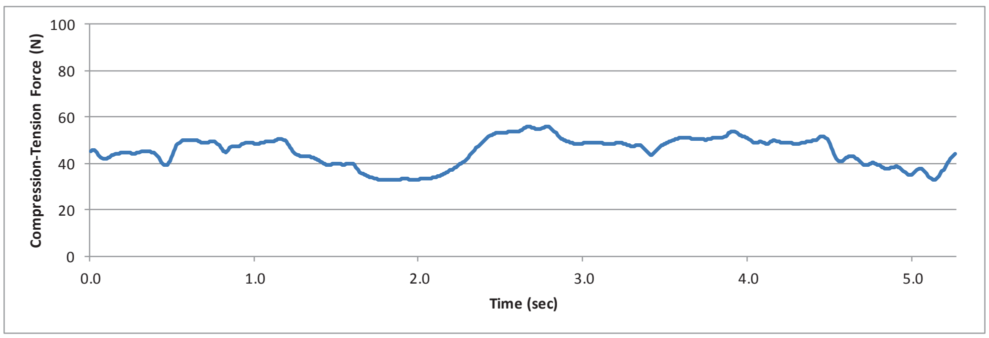
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	13.88	8.75
Left Lateral Bend	-10.81	-6.22
Left Axial Rotation	35.29	18.75
Right Axial Rotation	-69.43	-34.83
Extension	18.86	13.96
Flexion	-28.59	-15.90

Scan Regular Take-off – Day

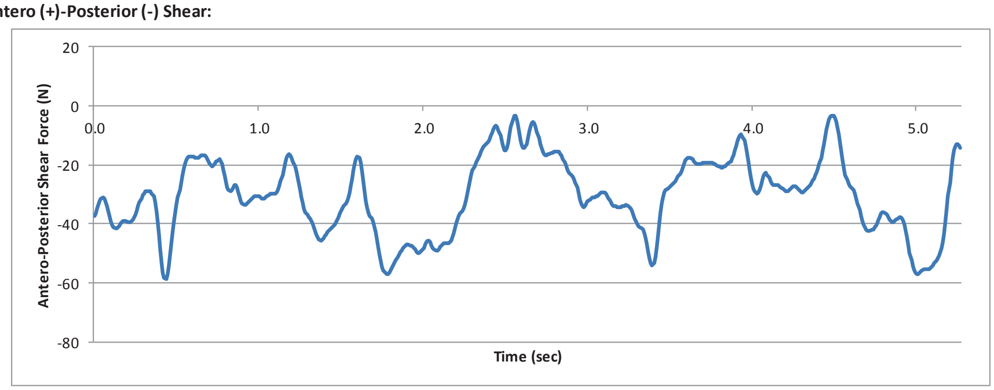
Resultant Neck Torque:



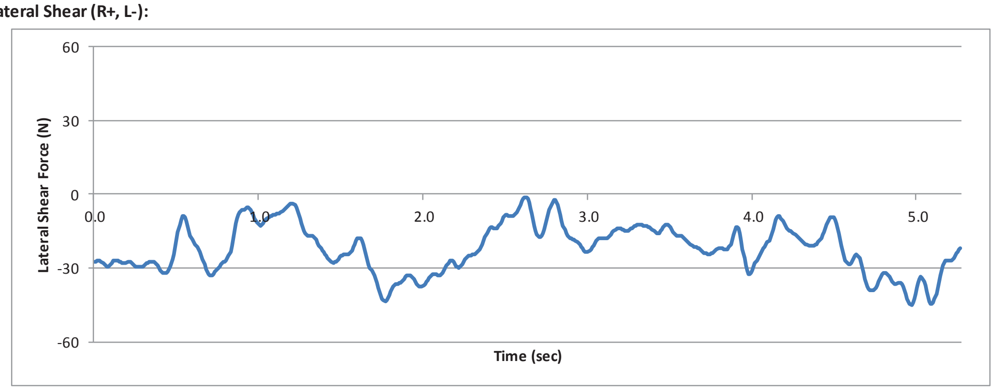
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



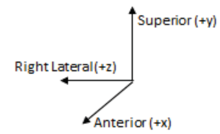
Lateral Shear (R+, L-):



Scan Regular Take-off - Night

Griffon MFTA - PDA: Postural Sequence

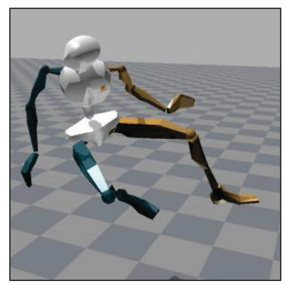
Postural Sequence:	Scan Regular Take-off (FE)
NIGHT	
Participant # (Sample Graphs):	FE03
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Kneeling in the door frame, the FE scans forward, side, back, and up.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

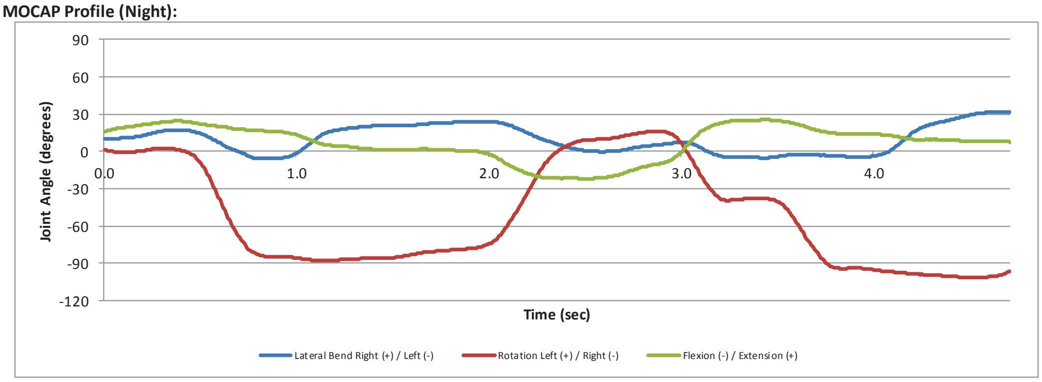
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	8.181	seconds

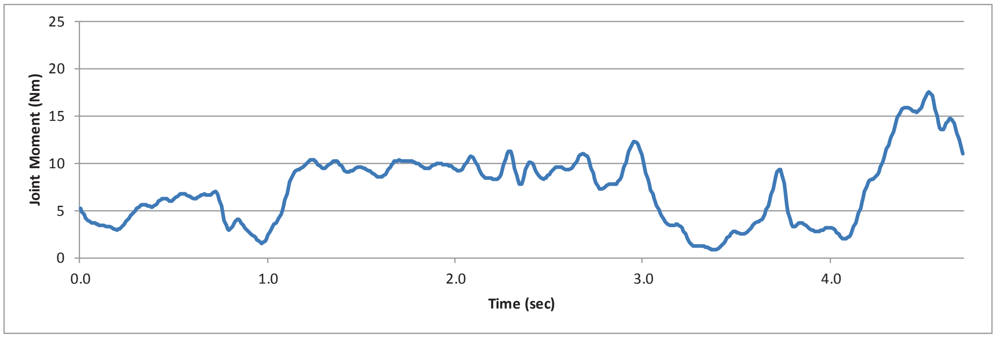
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	69.99	61.19	501.10
Tension (N)	NA	NA	NA
Anterior Shear (N)	3.25	1.64	0.12
Posterior Shear (N)	-61.12	-38.44	-314.28
Right Lateral Shear (N)	19.12	10.68	24.22
Left Lateral Shear (N)	-29.01	-15.02	-94.61
Torque (Resultant) (Nm)	14.71	7.47	61.17
Right Lateral Moment (+Mx) (Nm	3.18	1.53	4.97
Left Lateral Moment (-Mx) (Nm)	-5.14	-2.50	-12.36
Left Axial Moment (+My) (Nm)	3.45	1.34	7.07
Right Axial Moment (-My) (Nm)	-2.81	-1.15	-3.35
Extension Moment (+Mz) (Nm)	11.68	6.72	50.85
Flexion Moment (-Mz) (Nm)	-1.91	-0.91	-0.85

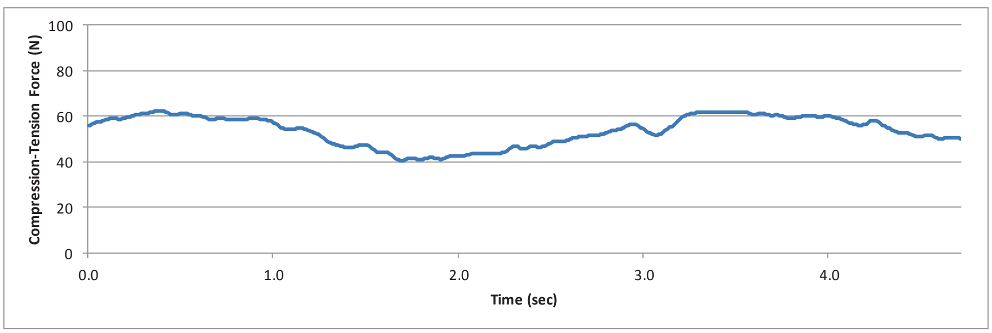
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	19.96	8.83
Left Lateral Bend	-16.57	-11.95
Left Axial Rotation	37.89	23.85
Right Axial Rotation	-76.94	-39.79
Extension	20.07	12.51
Flexion	-38.91	-23.10

Scan Regular Take-off - Night

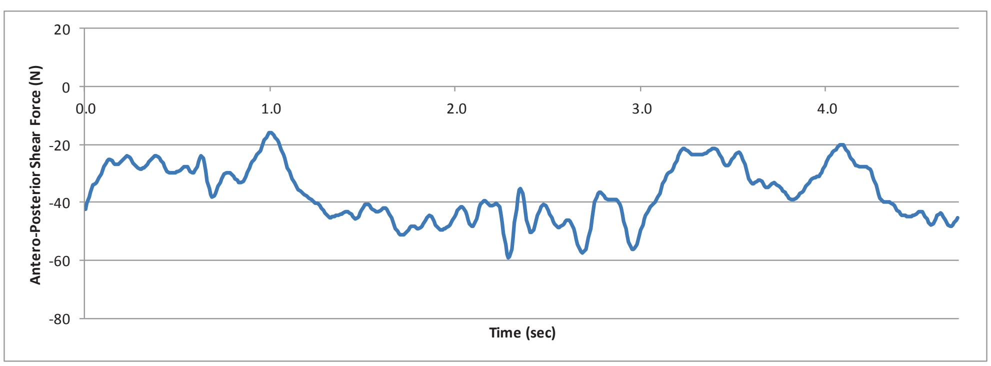
Resultant Neck Torque:



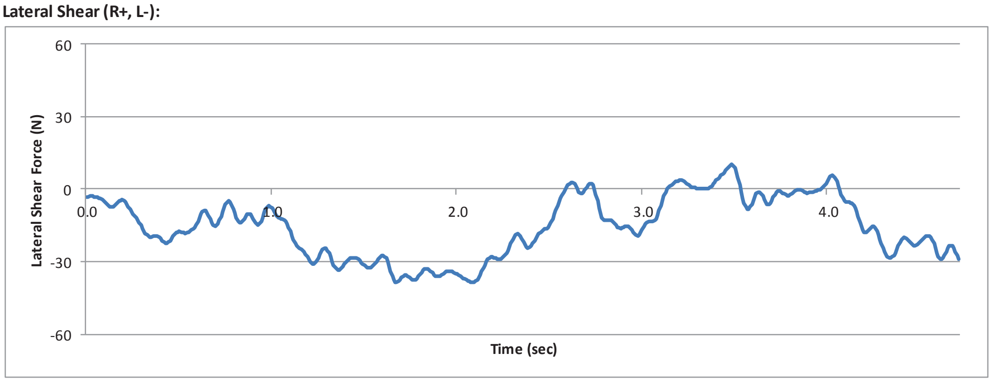
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:

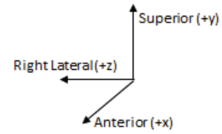


Lateral Shear (R+, L-):



Scan Seated Door Closed – Day

Griffon MFTA - PDA: Postural Sequence

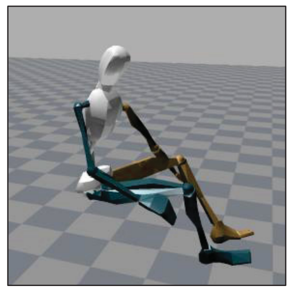


Postural Sequence:	Scan Seated Door Closed (FE)
DAY	
Participant # (Sample Graphs):	FE03
Role:	Flight Engineer
Helmet Condition:	Helmet Only

Task Description:	Equipment Considerations:
Seated on the jump seat facing forward, the FE scans outside the cabin window to the front, side and rear with the door closed.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

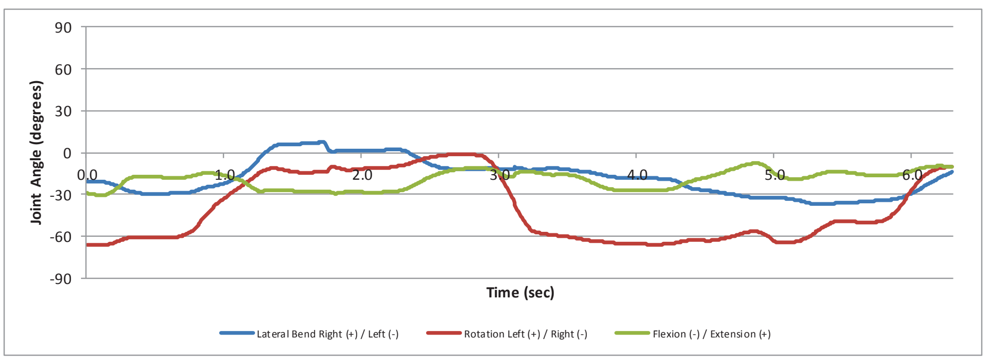
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



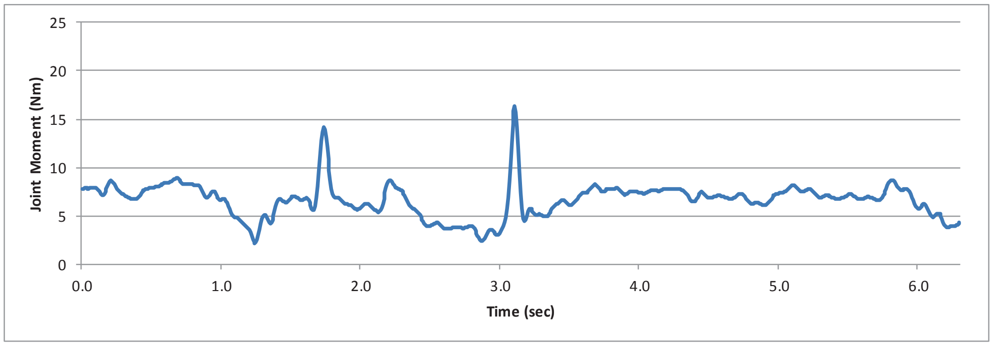
Posture Duration:	7.792	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

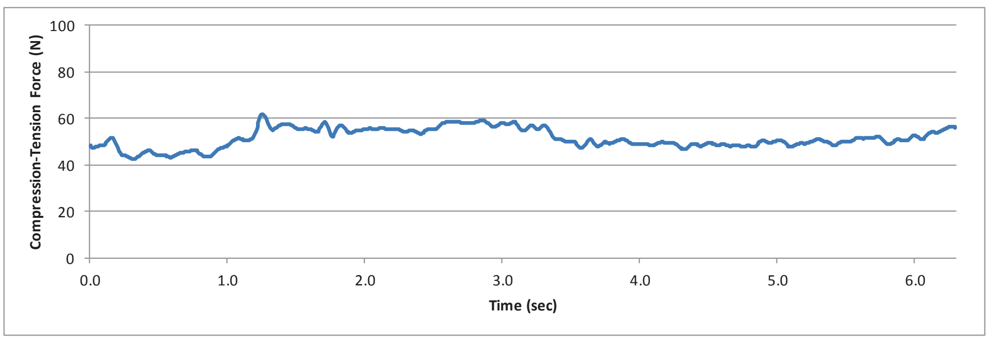
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	60.64	55.51	432.98	Right Lateral Bend	21.21	13.07
Tension (N)	NA	NA	NA	Left Lateral Bend	-28.80	-20.23
Anterior Shear (N)	11.64	2.80	1.02	Left Axial Rotation	46.04	31.18
Posterior Shear (N)	-33.85	-14.72	-109.46	Right Axial Rotation	-71.08	-41.73
Right Lateral Shear (N)	13.58	4.15	12.28	Extension	NA	NA
Left Lateral Shear (N)	-27.78	-9.87	-47.78	Flexion	-36.38	-22.60
Torque (Resultant) (Nm)	5.48	5.90	23.00			
Right Lateral Moment (+Mx) (Nm)	5.44	2.68	8.23			
Left Lateral Moment (-Mx) (Nm)	-6.21	-2.83	-16.31			
Left Axial Moment (+My) (Nm)	2.50	1.00	4.45			
Right Axial Moment (-My) (Nm)	-2.01	-0.67	-2.23			
Extension Moment (+Mz) (Nm)	7.38	4.71	36.72			
Flexion Moment (-Mz) (Nm)	NA	NA	NA			

Scan Seated Door Closed - Day

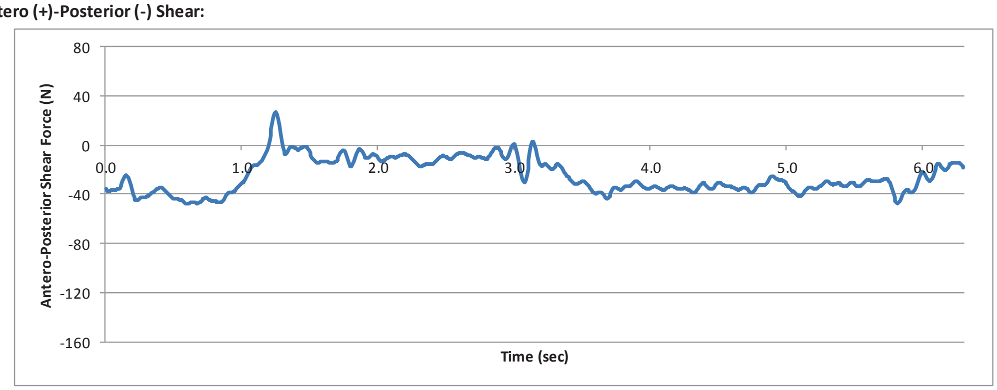
Resultant Neck Torque:



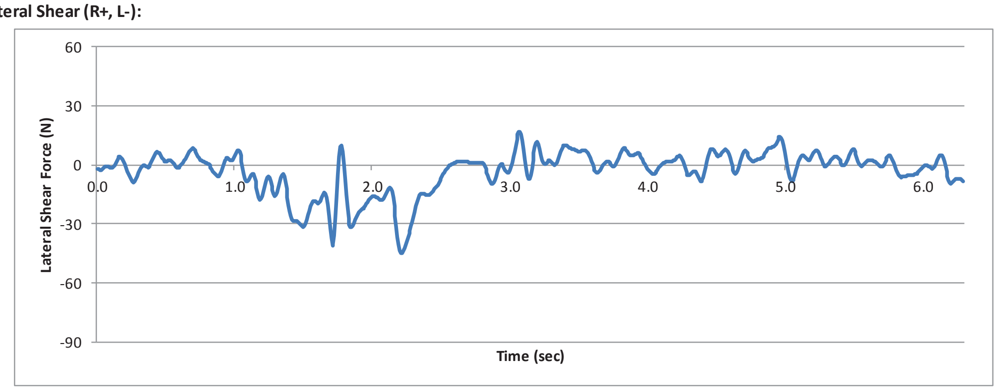
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



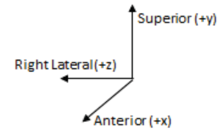
Lateral Shear (R+, L-):



Scan Seated Door Closed - Night

Griffon MFTA - PDA: Postural Sequence

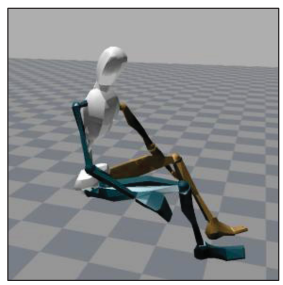
Postural Sequence:	Scan Seated Door Closed (FE)
NIGHT	
Participant # (Sample Graphs):	FE03
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Seated on the jump seat facing forward, the FE scans outside the cabin window to the front, side and rear with the door closed.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

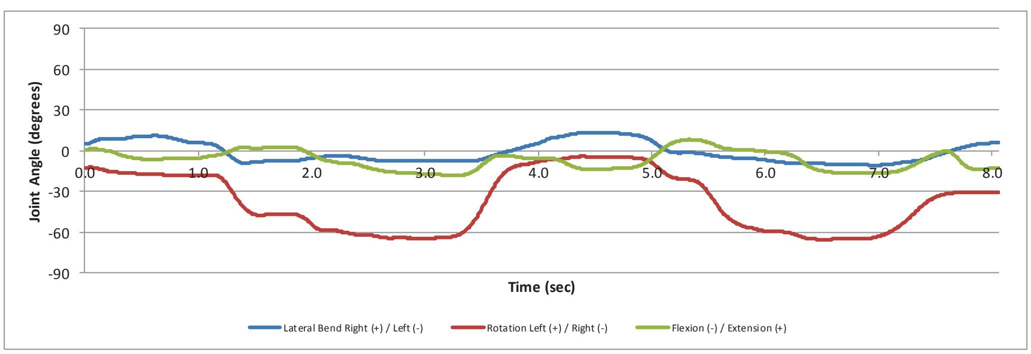
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



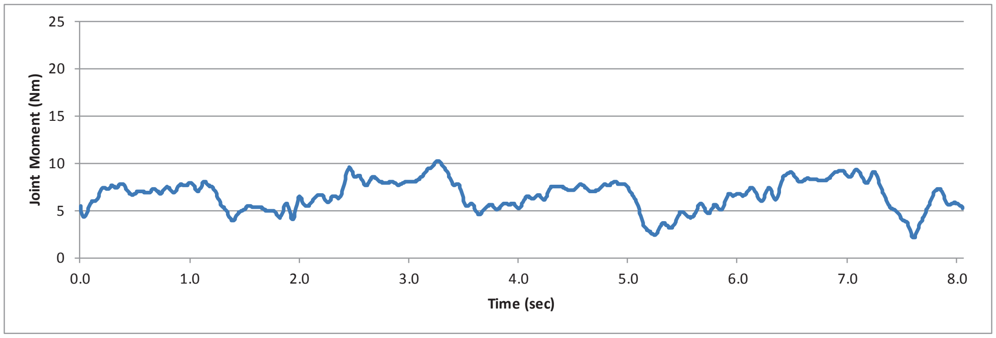
Posture Duration:	12.695	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

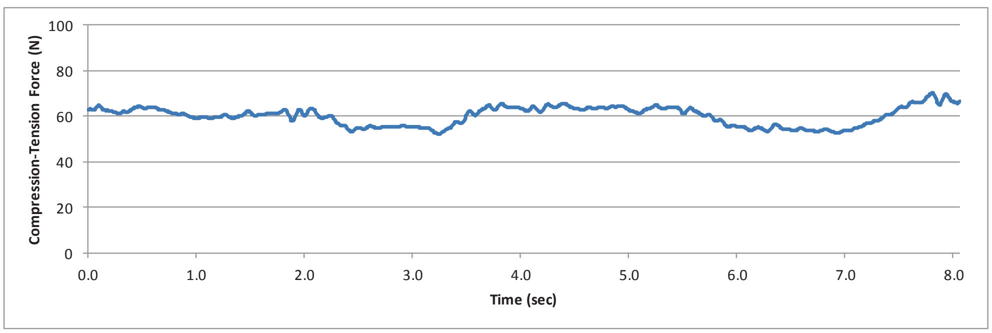
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	76.43	66.19	840.86	Right Lateral Bend	25.91	14.22
Tension (N)	NA	NA	NA	Left Lateral Bend	-11.47	-5.98
Anterior Shear (N)	32.18	9.50	48.04	Left Axial Rotation	28.53	21.88
Posterior Shear (N)	-77.50	-22.57	-195.40	Right Axial Rotation	-80.95	-50.65
Right Lateral Shear (N)	35.44	10.47	62.88	Extension	10.27	6.22
Left Lateral Shear (N)	-37.41	-21.88	-146.50	Flexion	-30.47	-15.66
Torque (Resultant) (Nm)	10.89	6.60	69.86			
Right Lateral Moment (+Mx) (Nm	4.34	2.24	6.00			
Left Lateral Moment (-Mx) (Nm)	-8.13	-3.79	-38.04			
Left Axial Moment (+My) (Nm)	2.38	1.16	5.84			
Right Axial Moment (-My) (Nm)	-3.69	-1.20	-9.25			
Extension Moment (+Mz) (Nm)	12.15	4.54	53.58			
Flexion Moment (-Mz) (Nm)	-4.34	-2.54	-3.77			

Scan Seated Door Closed - Night

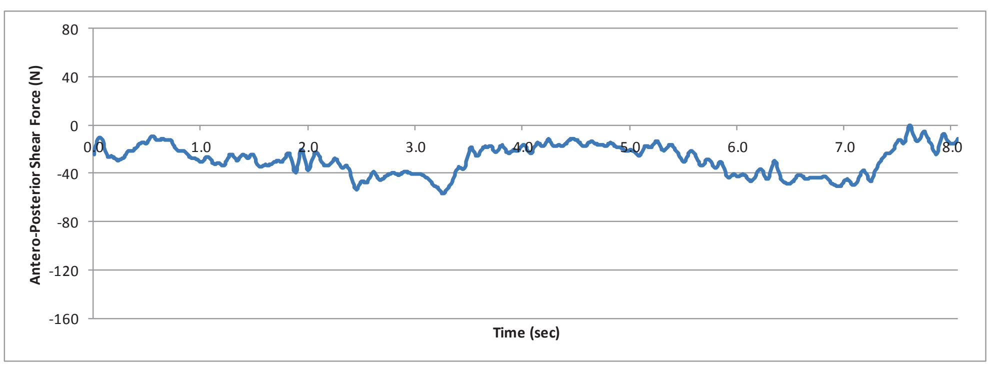
Resultant Neck Torque:



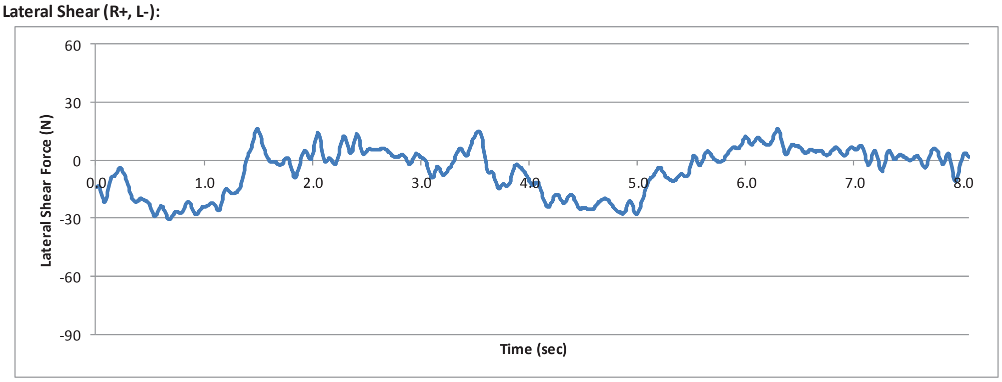
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



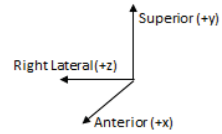
Lateral Shear (R+, L-):



Scan Slope Landing – Day

Griffon MFTA - PDA: Postural Sequence

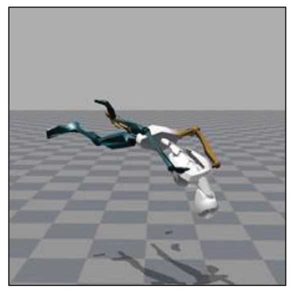
Postural Sequence:	Scan Sloped Landing (FE)
DAY	
Participant # (Sample Graphs):	FE01
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
Lying prone, the FE scans beneath the AC to observe the touchdown of the opposite skid (high side) before observing and calling the altitude of the low side skid until contact.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

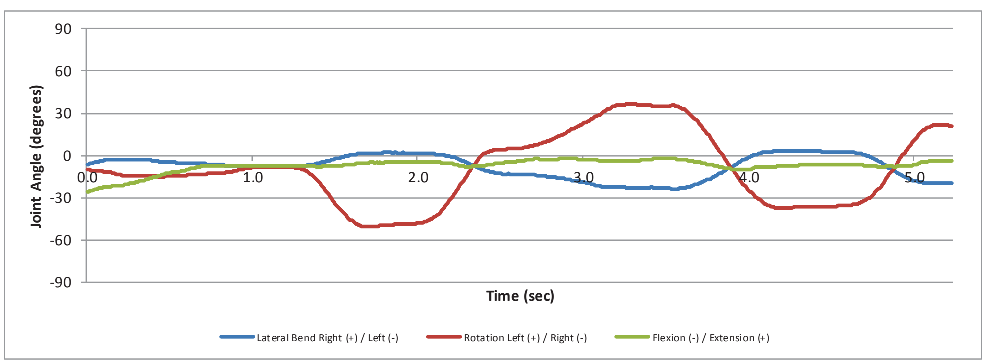
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



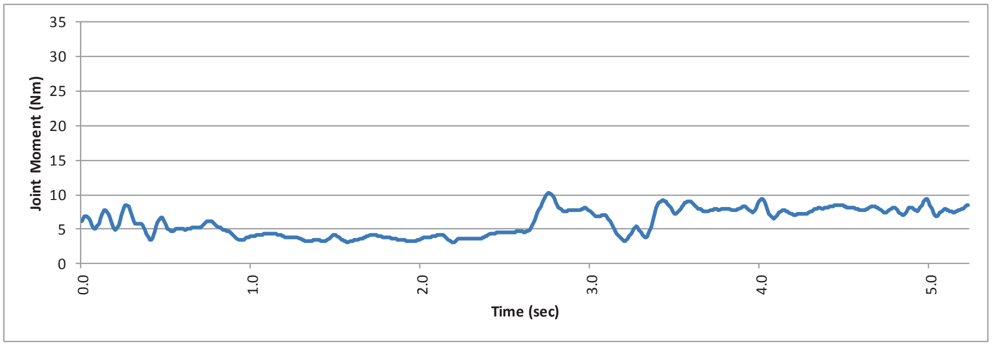
Posture Duration:	15.280	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

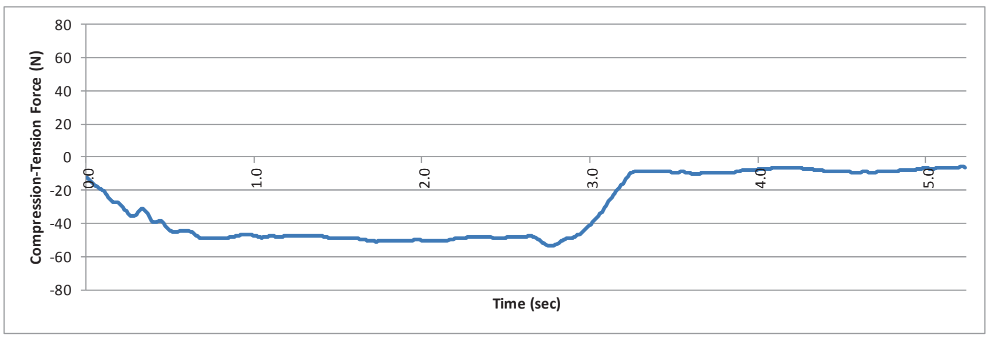
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	46.33	20.17	97.81	Right Lateral Bend	15.49	7.47
Tension (N)	-48.02	-29.85	-340.54	Left Lateral Bend	-14.57	-5.87
Anterior Shear (N)	19.00	9.41	0.76	Left Axial Rotation	38.23	22.65
Posterior Shear (N)	-120.68	-49.45	-752.87	Right Axial Rotation	-63.29	-35.60
Right Lateral Shear (N)	38.07	12.65	111.70	Extension	22.17	13.37
Left Lateral Shear (N)	-39.98	-11.64	-75.16	Flexion	-33.79	-15.50
Torque (Resultant) (Nm)	13.70	6.74	85.89			
Right Lateral Moment (+Mx) (Nm)	5.12	1.76	16.82			
Left Lateral Moment (-Mx) (Nm)	-5.41	-1.42	-8.17			
Left Axial Moment (+My) (Nm)	3.41	0.88	4.26			
Right Axial Moment (-My) (Nm)	-2.70	-1.04	-10.80			
Extension Moment (+Mz) (Nm)	15.68	5.94	90.53			
Flexion Moment (-Mz) (Nm)	-2.41	-1.45	-0.07			

Scan Slope Landing – Day

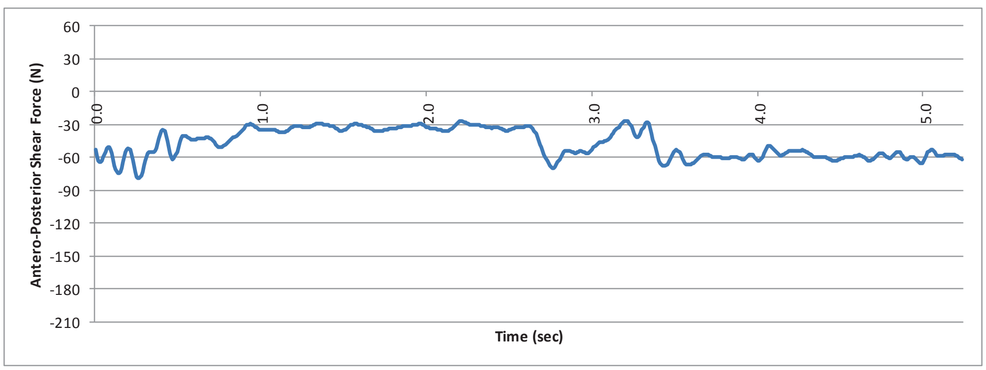
Resultant Neck Torque:



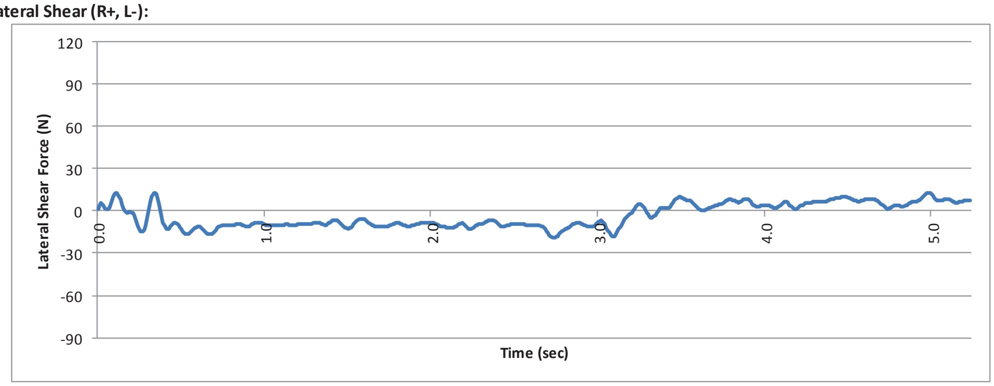
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



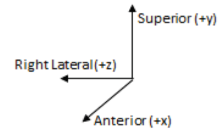
Lateral Shear (R+, L-):



Scan Slope Landing –Night

Griffon MFTA - PDA: Postural Sequence

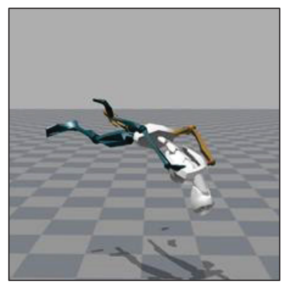
Postural Sequence:	Scan Sloped Landing (FE)
NIGHT	
Participant # (Sample Graphs):	FE01
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Lying prone, the FE scans beneath the AC to observe the touchdown of the opposite skid (high side) before observing and calling the altitude of the low side skid until contact.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

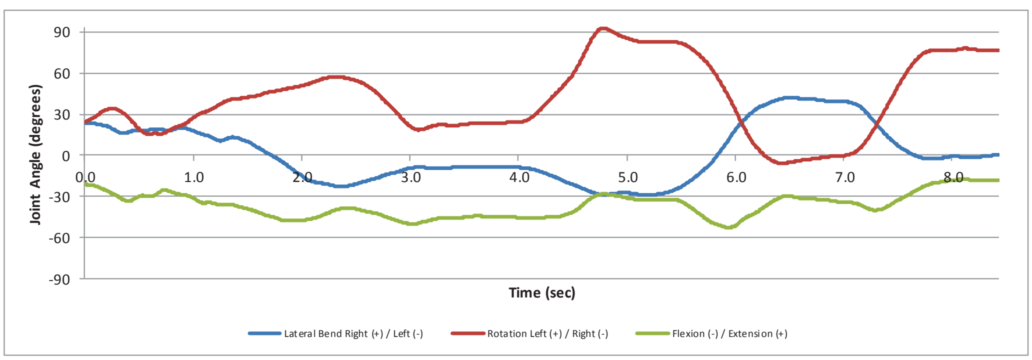
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



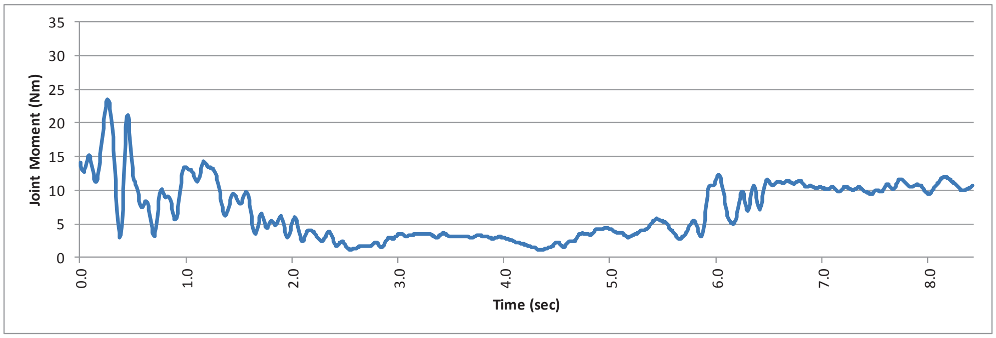
Posture Duration:	12.119	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

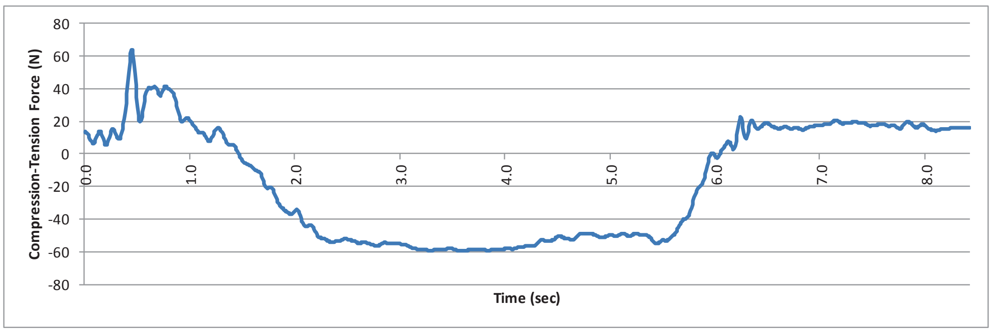
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	45.08	23.03	99.06	Right Lateral Bend	20.04	10.39
Tension (N)	-50.01	-30.28	-236.97	Left Lateral Bend	-19.09	-9.37
Anterior Shear (N)	29.91	16.72	1.36	Left Axial Rotation	52.83	24.26
Posterior Shear (N)	-146.43	-60.52	-730.70	Right Axial Rotation	-50.20	-28.72
Right Lateral Shear (N)	59.45	27.02	195.12	Extension	22.20	12.81
Left Lateral Shear (N)	-51.09	-20.12	-98.75	Flexion	-51.10	-31.68
Torque (Resultant) (Nm)	23.80	7.53	91.26			
Right Lateral Moment (+Mx) (Nm	7.57	2.53	18.61			
Left Lateral Moment (-Mx) (Nm)	-6.86	-2.39	-11.42			
Left Axial Moment (+My) (Nm)	4.33	1.65	6.50			
Right Axial Moment (-My) (Nm)	-6.96	-2.43	-19.94			
Extension Moment (+Mz) (Nm)	19.14	5.98	65.80			
Flexion Moment (-Mz) (Nm)	-3.16	-1.11	-1.50			

Scan Slope Landing – Night

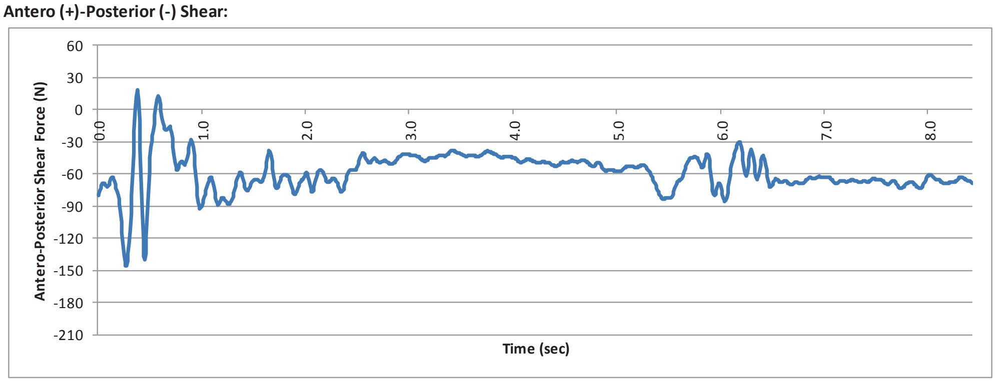
Resultant Neck Torque:



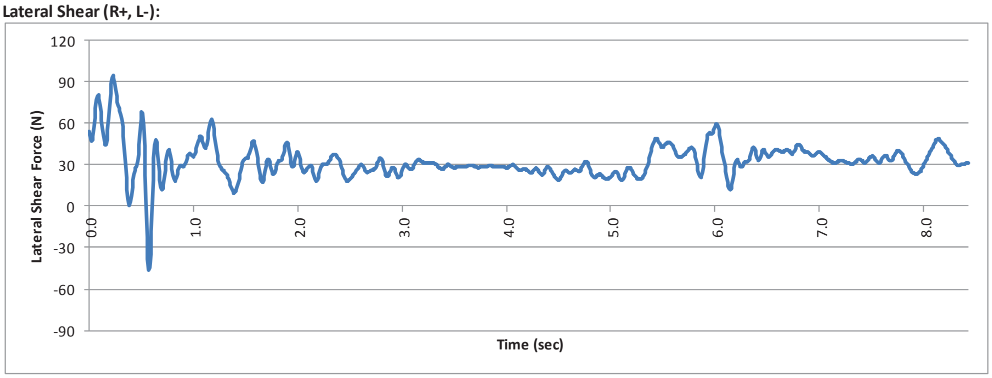
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



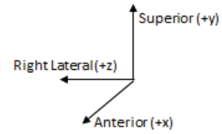
Lateral Shear (R+, L-):



Scan Slung Load - Day

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Scan Slung Load (FE)
DAY	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet Only



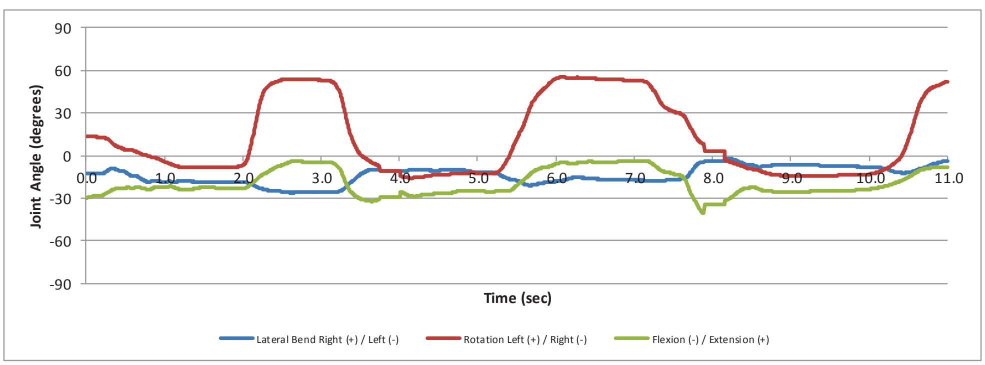
Task Description:	Equipment Considerations:
Kneeling in the door frame, the FE scans down between the door sill and the skid to observe the status of the slung load.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



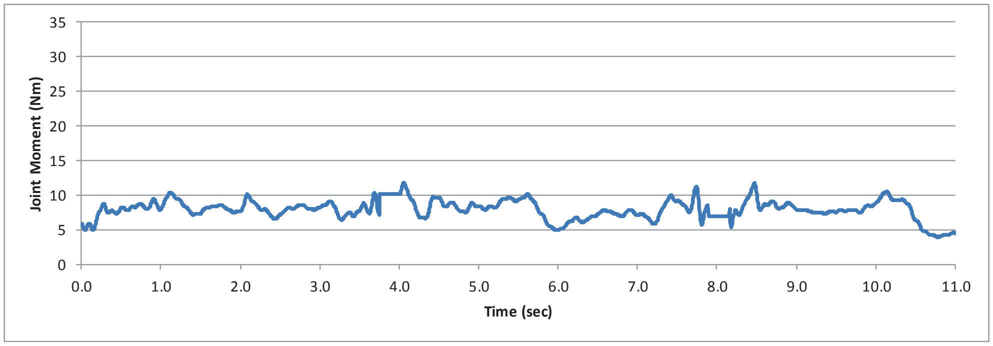
Posture Duration:	5.626	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

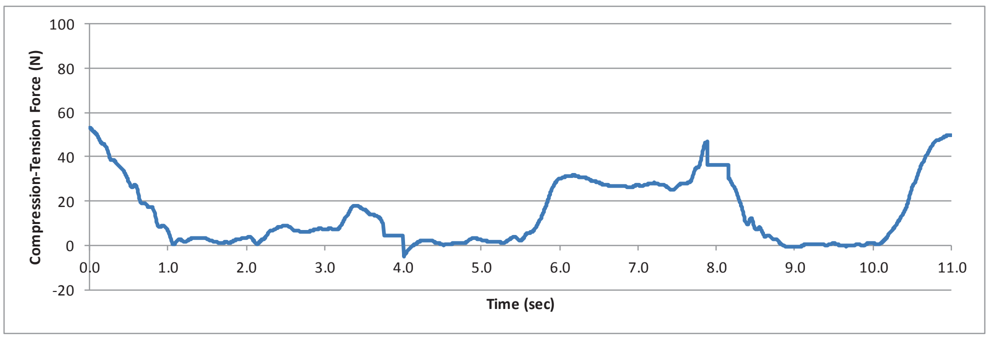
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	51.96	31.21	172.89	Right Lateral Bend	11.69	11.04
Tension (N)	-4.85	-0.77	-0.44	Left Lateral Bend	-18.20	-9.57
Anterior Shear (N)	NA	NA	NA	Left Axial Rotation	29.08	24.01
Posterior Shear (N)	-61.19	-43.42	-244.68	Right Axial Rotation	-58.21	-30.71
Right Lateral Shear (N)	16.74	10.94	16.07	Extension	8.09	4.04
Left Lateral Shear (N)	-24.47	-17.40	-76.76	Flexion	-37.21	-25.05
Torque (Resultant) (Nm)	13.64	7.86	44.29			
Right Lateral Moment (+Mx) (Nm)	2.29	1.23	2.02			
Left Lateral Moment (-Mx) (Nm)	-2.88	-1.89	-7.56			
Left Axial Moment (+My) (Nm)	3.89	2.03	11.12			
Right Axial Moment (-My) (Nm)	-1.84	-1.34	-2.16			
Extension Moment (+Mz) (Nm)	9.65	6.99	39.40			
Flexion Moment (-Mz) (Nm)	NA	NA	NA			

Scan Slung Load - Day

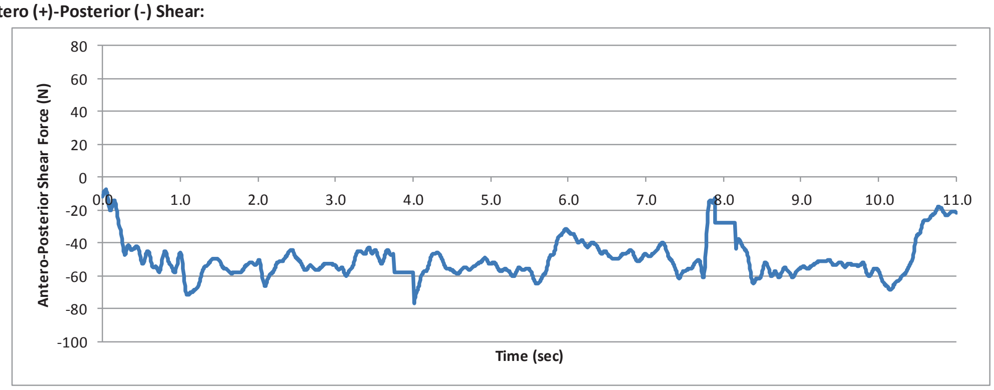
Resultant Neck Torque:



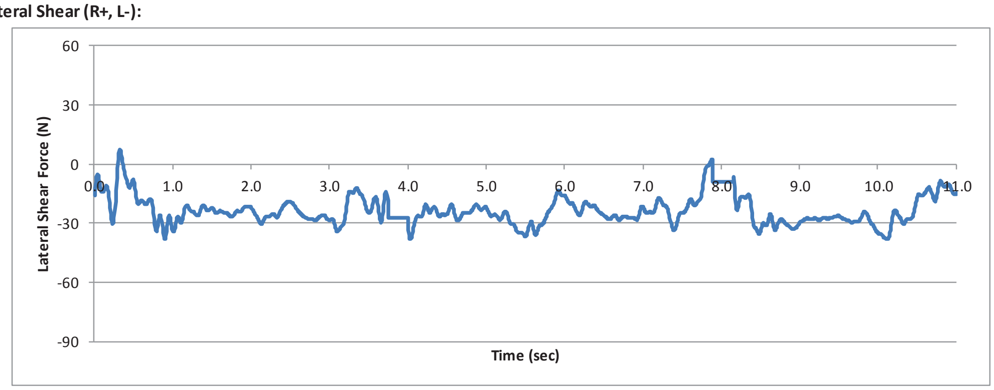
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):



Scan Slung Load – Night

Griffon MFTA - PDA: Postural Sequence

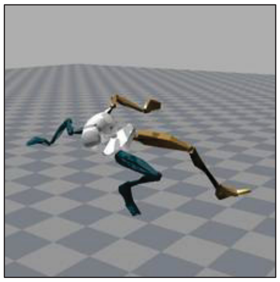
Postural Sequence:	Scan Slung Load (FE)
NIGHT	
Participant # (Sample Graphs):	FE05
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG

Superior (+y)
Right Lateral (+z)
Anterior (+x)

Task Description:	**Equipment Considerations:**
Kneeling in the door frame, the FE scans down between the door sill and the skid to observe the status of the slung load.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

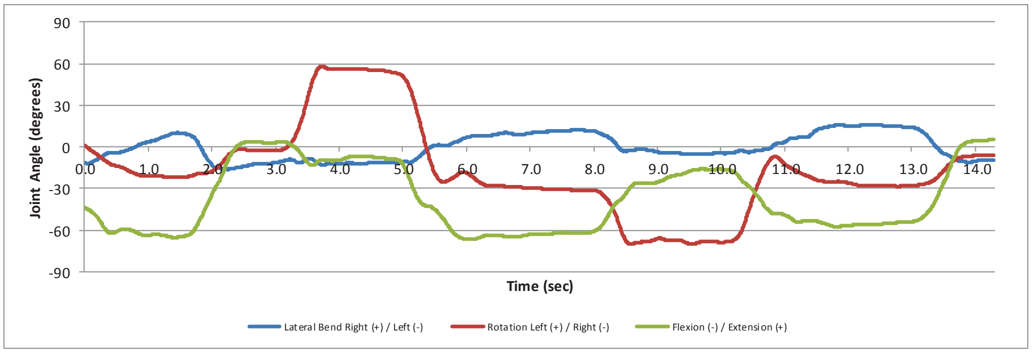
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



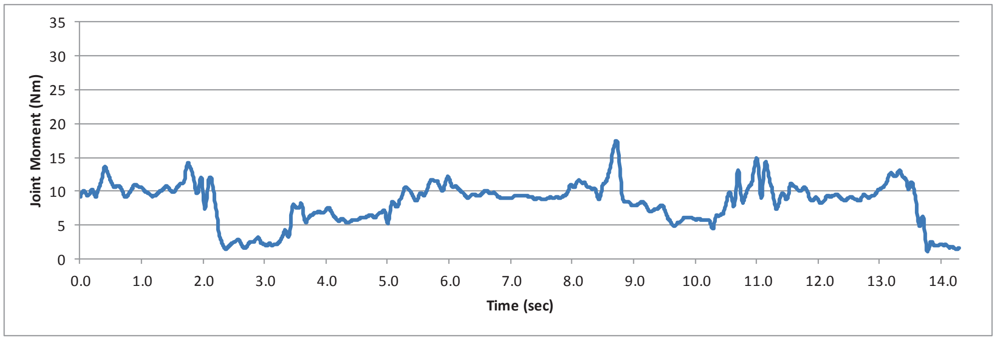
Posture Duration:	7.974	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

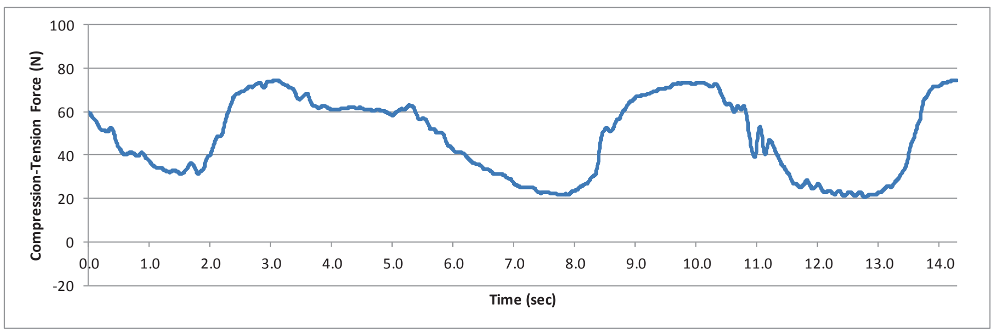
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	58.29	45.08	359.79	Right Lateral Bend	20.75	14.69
Tension (N)	NA	NA	NA	Left Lateral Bend	-14.89	-9.75
Anterior Shear (N)	NA	NA	NA	Left Axial Rotation	43.75	29.37
Posterior Shear (N)	-80.53	-48.33	-385.73	Right Axial Rotation	-43.48	-24.86
Right Lateral Shear (N)	15.05	10.48	22.47	Extension	13.21	8.03
Left Lateral Shear (N)	-42.28	-25.60	-176.89	Flexion	-55.16	-38.26
Torque (Resultant) (Nm)	16.66	9.10	72.64			
Right Lateral Moment (+Mx) (Nm	1.82	1.83	6.88			
Left Lateral Moment (-Mx) (Nm)	-5.61	-3.21	-19.61			
Left Axial Moment (+My) (Nm)	4.42	2.55	17.04			
Right Axial Moment (-My) (Nm)	-2.58	-1.69	-4.07			
Extension Moment (+Mz) (Nm)	11.70	7.68	61.28			
Flexion Moment (-Mz) (Nm)	-0.05	-0.05	0.00			

Scan Slung Load - Night

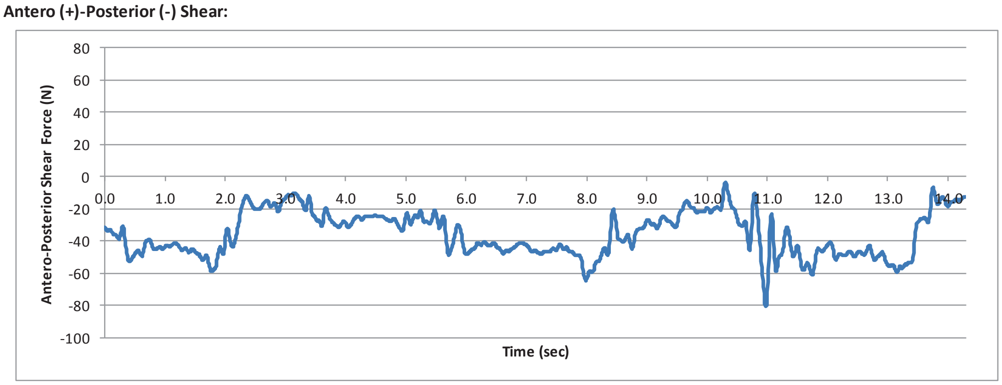
Resultant Neck Torque:



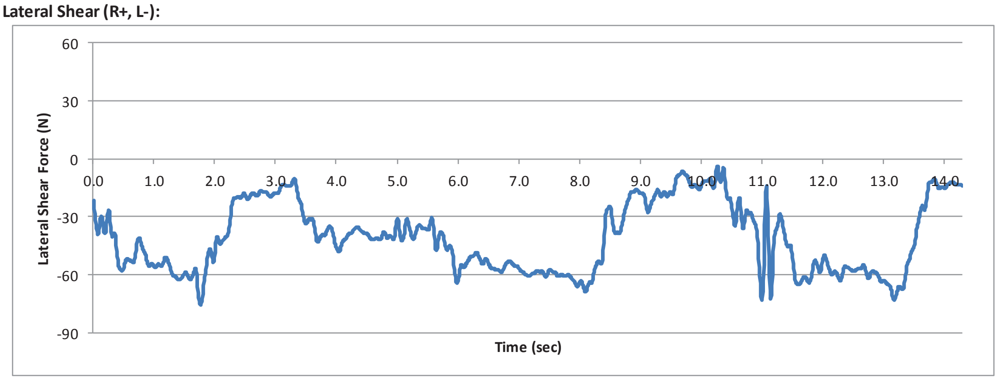
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



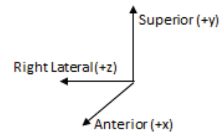
Lateral Shear (R+, L-):



Scan Troops on Sill – Day

Griffon MFTA - PDA: Postural Sequence

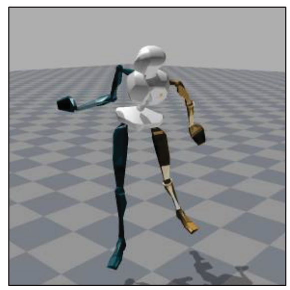
Postural Sequence:	Scan Troops on Sill (FE)
DAY	
Participant # (Sample Graphs):	FE01
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
Troops are sitting on the sill ready to disembark so the FE must stoop over the troops in the confined head room to perform their scan checks.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

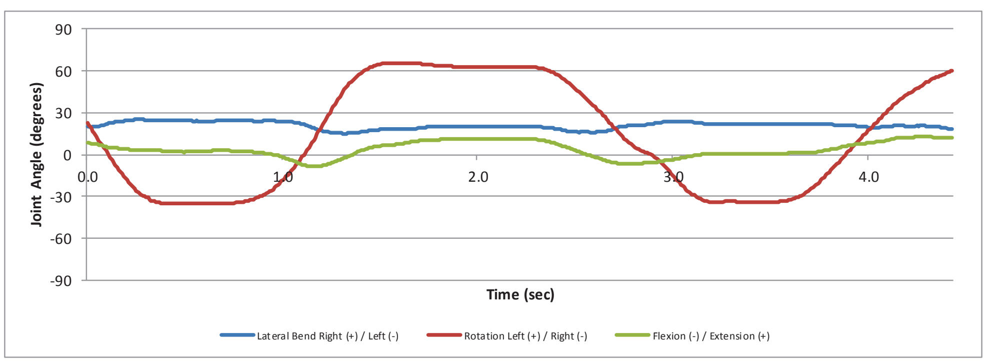
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	9.436	seconds

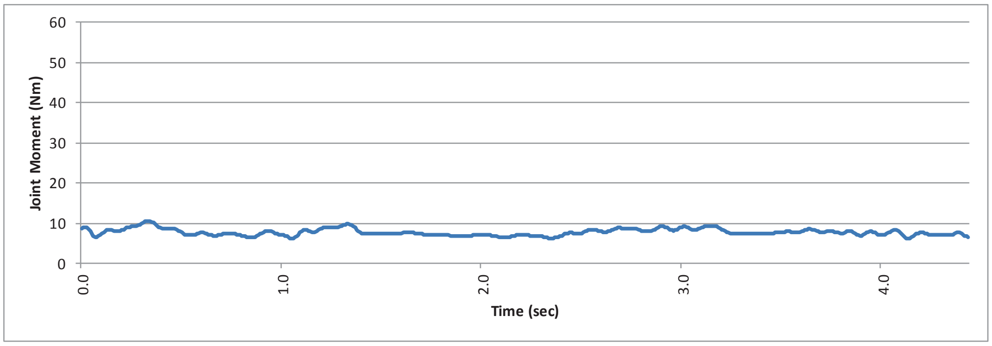
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	31.45	25.39	239.83
Tension (N)	NA	NA	NA
Anterior Shear (N)	2.77	1.97	0.05
Posterior Shear (N)	-74.45	-48.42	-457.07
Right Lateral Shear (N)	23.24	12.87	41.28
Left Lateral Shear (N)	-37.32	-16.20	-164.53
Torque (Resultant) (Nm)	15.35	7.81	73.76
Right Lateral Moment (+Mx) (Nm)	3.58	1.17	5.38
Left Lateral Moment (-Mx) (Nm)	-3.81	-2.34	-15.82
Left Axial Moment (+My) (Nm)	3.49	1.30	8.31
Right Axial Moment (-My) (Nm)	-2.25	-1.24	-6.17
Extension Moment (+Mz) (Nm)	10.38	6.80	64.22
Flexion Moment (-Mz) (Nm)	NA	NA	NA

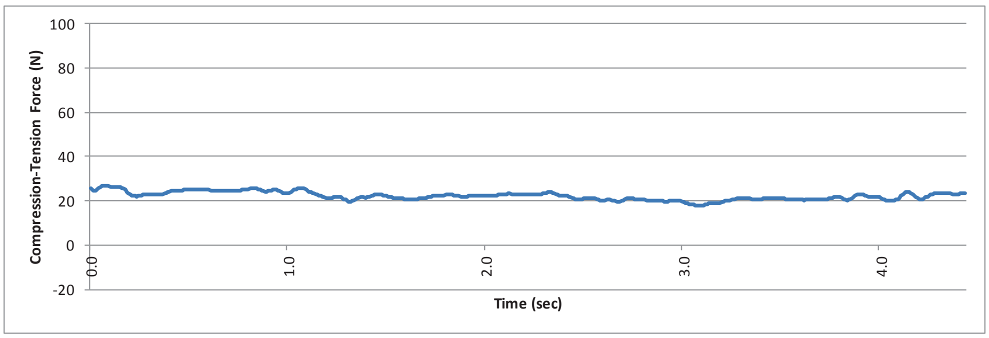
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	15.59	9.39
Left Lateral Bend	-18.37	-8.85
Left Axial Rotation	44.08	24.87
Right Axial Rotation	-67.67	-51.31
Extension	13.73	7.38
Flexion	-21.23	-11.27

Scan Troops on Sill - Day

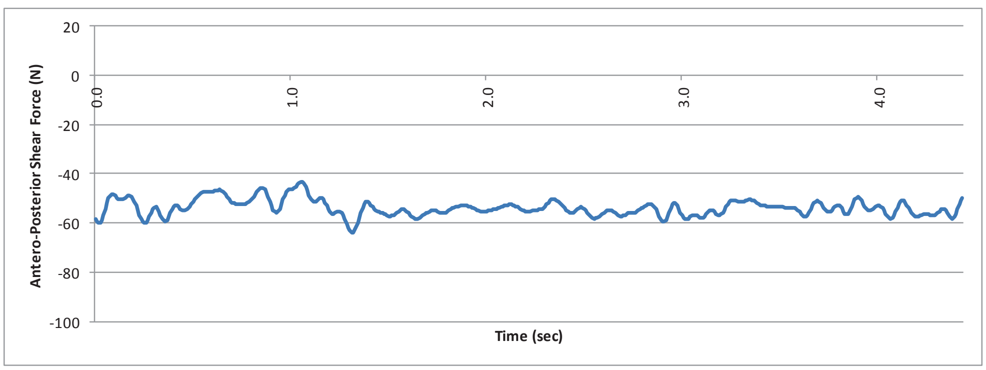
Resultant Neck Torque:



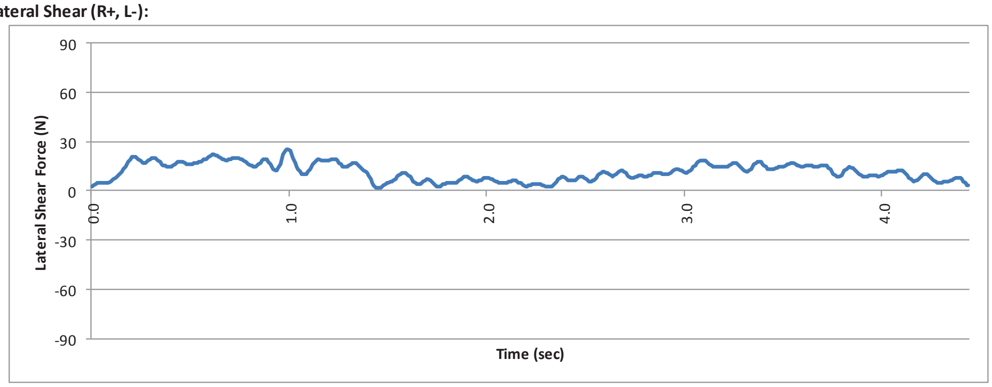
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



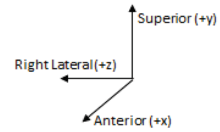
Lateral Shear (R+, L-):



Scan Troops on Sill – Night

Griffon MFTA - PDA: Postural Sequence

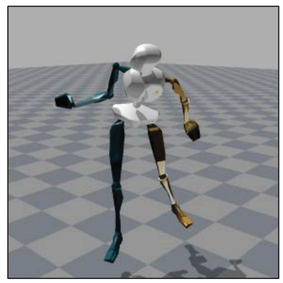
Postural Sequence:	Scan Troops on Sill (FE)
NIGHT	
Participant # (Sample Graphs):	FE01
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
Troops are sitting on the sill ready to disembark so the FE must stoop over the troops in the confined head room to perform their scan checks.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

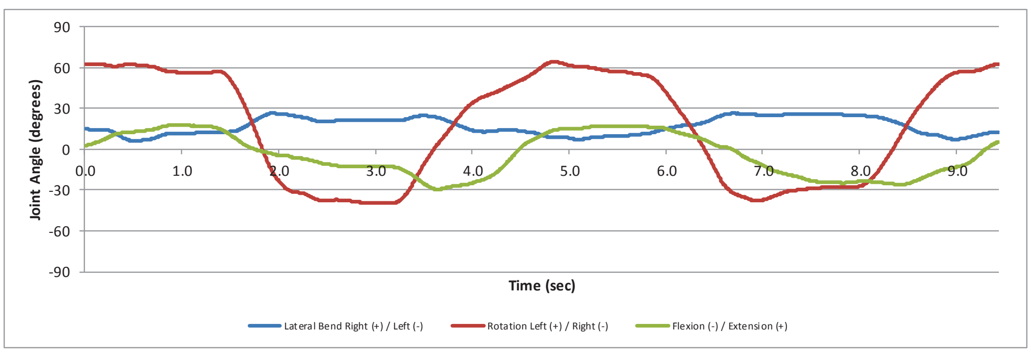
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



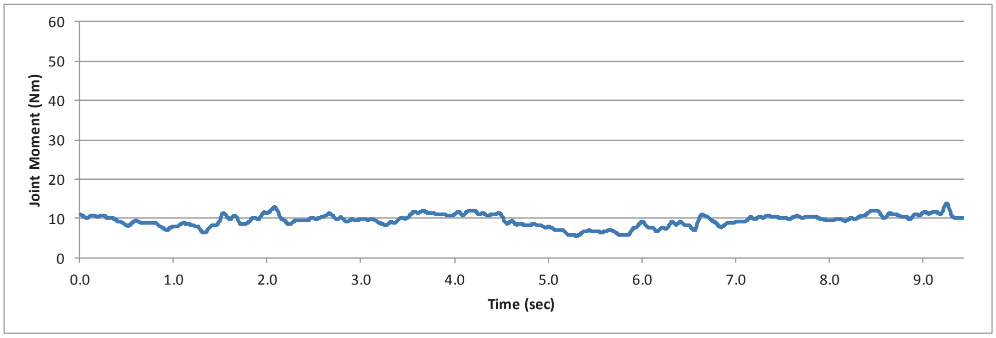
Posture Duration:	8.410	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

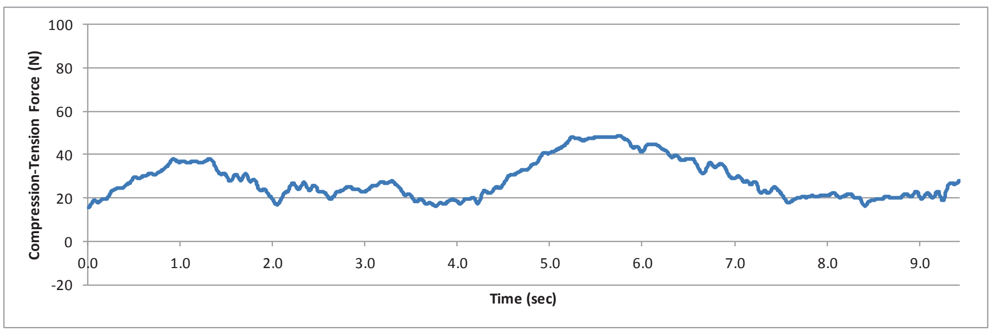
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	48.21	35.02	293.69	Right Lateral Bend	14.04	11.96
Tension (N)	-7.37	-4.44	-0.81	Left Lateral Bend	-17.00	-11.17
Anterior Shear (N)	NA	NA	NA	Left Axial Rotation	58.16	37.11
Posterior Shear (N)	-92.47	-62.54	-526.46	Right Axial Rotation	-68.47	-36.54
Right Lateral Shear (N)	36.15	18.10	60.56	Extension	18.02	10.40
Left Lateral Shear (N)	-30.72	-12.17	-61.71	Flexion	-28.26	-14.84
Torque (Resultant) (Nm)	25.77	10.07	84.78			
Right Lateral Moment (+Mx) (Nm	4.52	2.25	7.05			
Left Lateral Moment (-Mx) (Nm)	-4.02	-1.46	-7.69			
Left Axial Moment (+My) (Nm)	4.36	1.59	7.49			
Right Axial Moment (-My) (Nm)	-3.67	-2.28	-10.27			
Extension Moment (+Mz) (Nm)	13.88	8.56	71.94			
Flexion Moment (-Mz) (Nm)	-1.63	-0.61	-0.03			

Scan Troops on Sill - Night

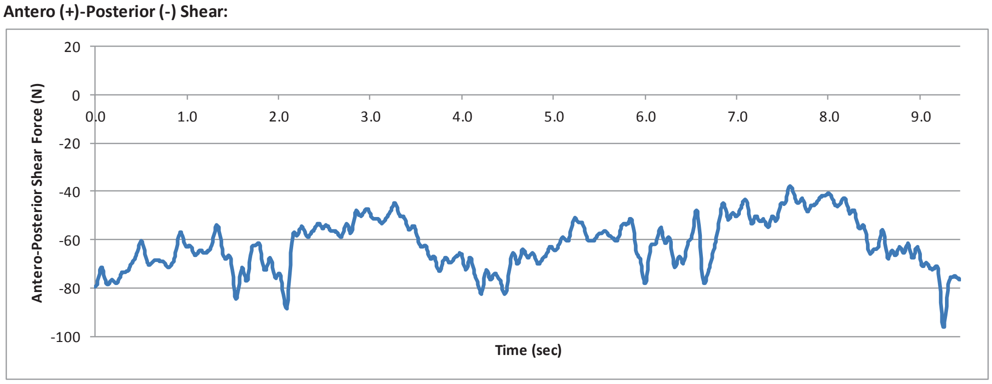
Resultant Neck Torque:



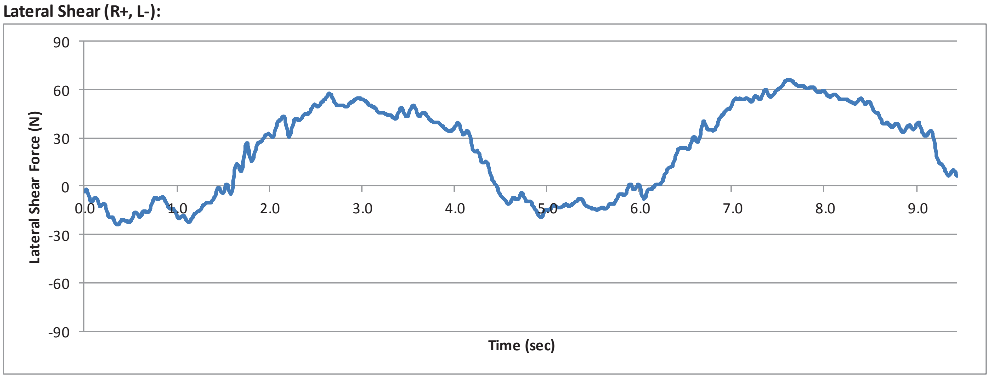
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



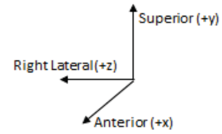
Lateral Shear (R+, L-):



Sling Hook-up Manual - Day

Griffon MFTA - PDA: Postural Sequence

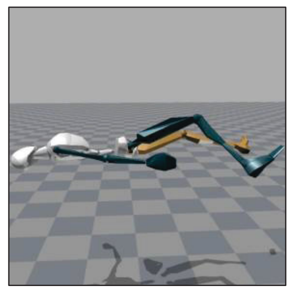
Postural Sequence:	Sling Hook-up Manual (FE)
DAY	
Participant # (Sample Graphs):	FE04
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
FE departs AC with sling, hooks up D ring to load, extends sling under AC, crawls under AC at cabin door, and connects sling eyelet to AC hook. The FE then returns to the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) 20' Sling

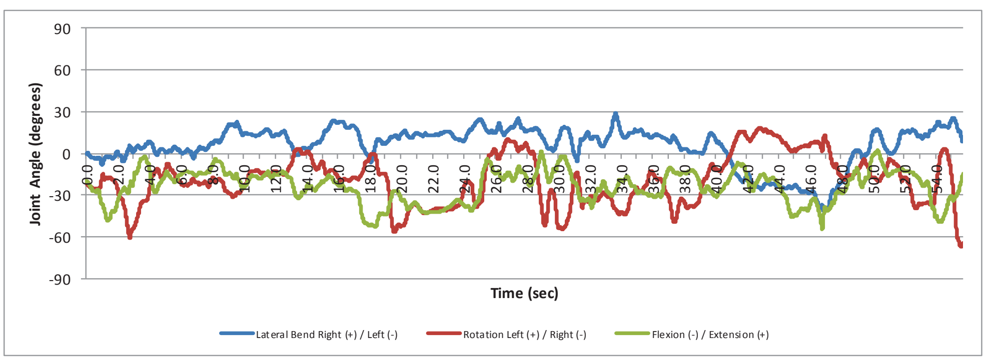
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



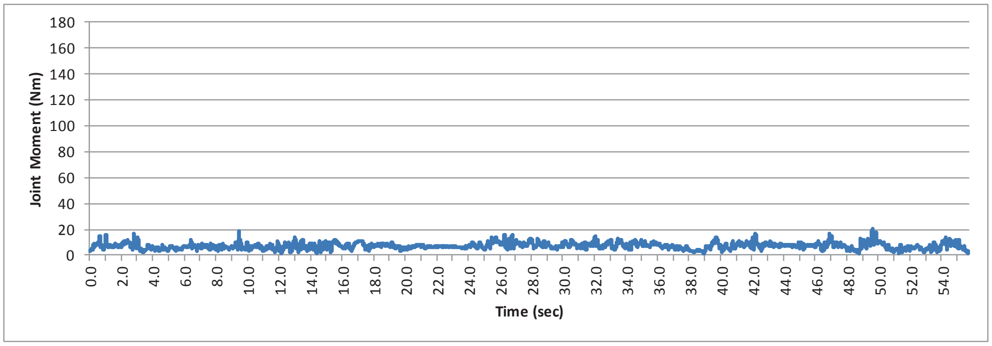
Posture Duration:	54.058	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

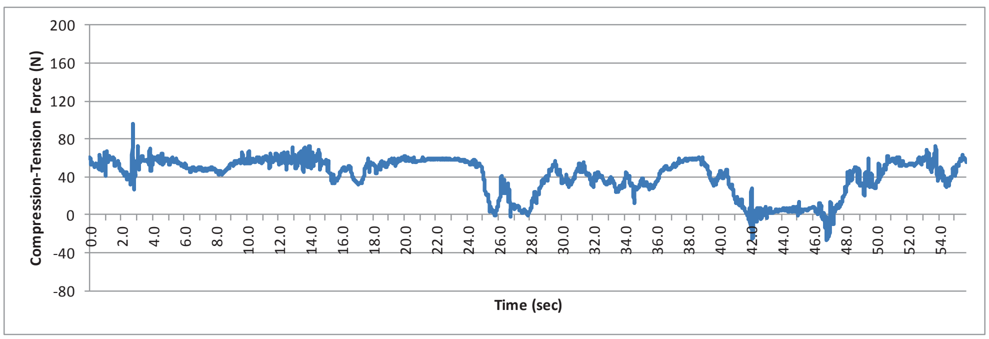
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	109.94	44.49	2224.70	Right Lateral Bend	29.02	11.95
Tension (N)	-41.12	-7.75	-31.44	Left Lateral Bend	-26.40	-9.86
Anterior Shear (N)	181.13	28.58	411.15	Left Axial Rotation	27.57	11.67
Posterior Shear (N)	-181.91	-30.62	-1215.09	Right Axial Rotation	-61.78	-26.22
Right Lateral Shear (N)	125.61	17.32	499.21	Extension	10.72	5.43
Left Lateral Shear (N)	-141.10	-16.26	-410.41	Flexion	-44.73	-19.98
Torque (Resultant) (Nm)	44.46	7.26	261.52			
Right Lateral Moment (+Mx) (Nm)	16.01	2.28	49.02			
Left Lateral Moment (-Mx) (Nm)	-18.83	-2.46	-79.96			
Left Axial Moment (+My) (Nm)	6.84	0.72	12.03			
Right Axial Moment (-My) (Nm)	-9.61	-1.79	-66.72			
Extension Moment (+Mz) (Nm)	25.67	5.56	254.09			
Flexion Moment (-Mz) (Nm)	-23.26	-4.76	-39.80			

Sling Hook-up Manual - Day

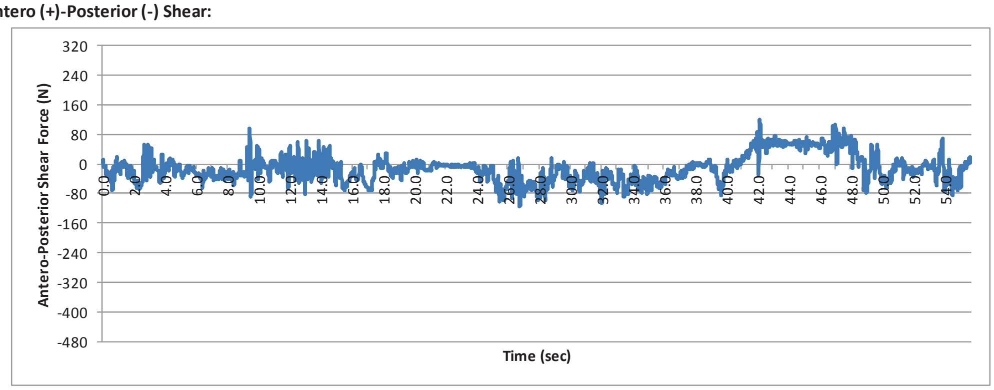
Resultant Neck Torque:



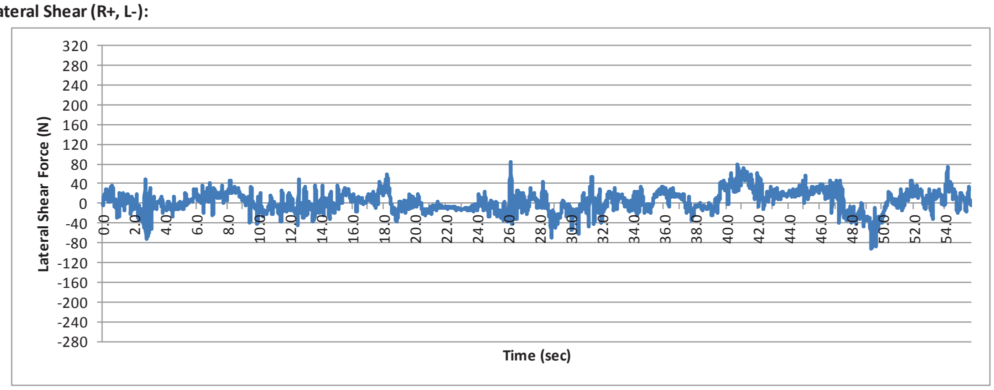
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



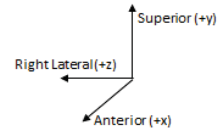
Lateral Shear (R+, L-):



Sling Hook-up Manual – Night

Griffon MFTA - PDA: Postural Sequence

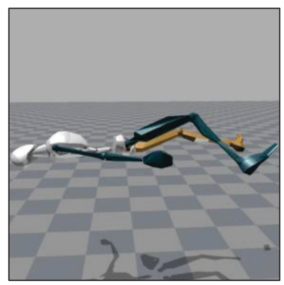
Postural Sequence:	Sling Hook-up Manual (FE)
NIGHT	
Participant # (Sample Graphs):	FE04
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
FE departs AC with sling, hooks up D ring to load, extends sling under AC, crawls under AC at cabin door, and connects sling eyelet to AC hook. The FE then returns to the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) 20' Sling

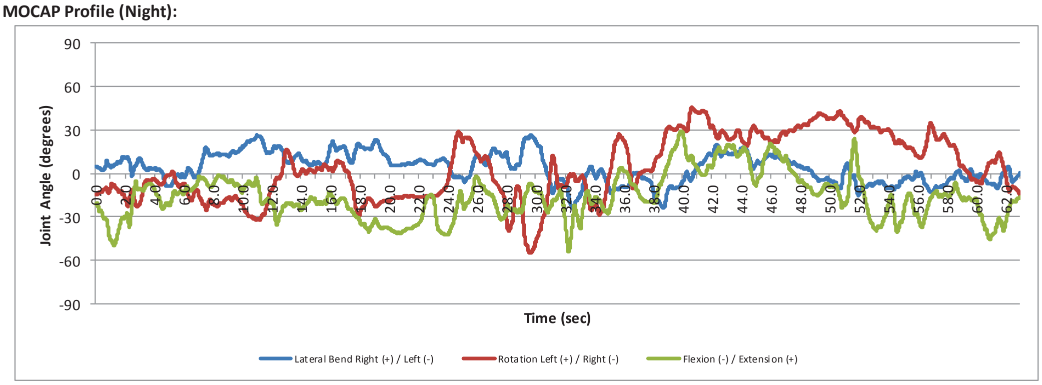
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



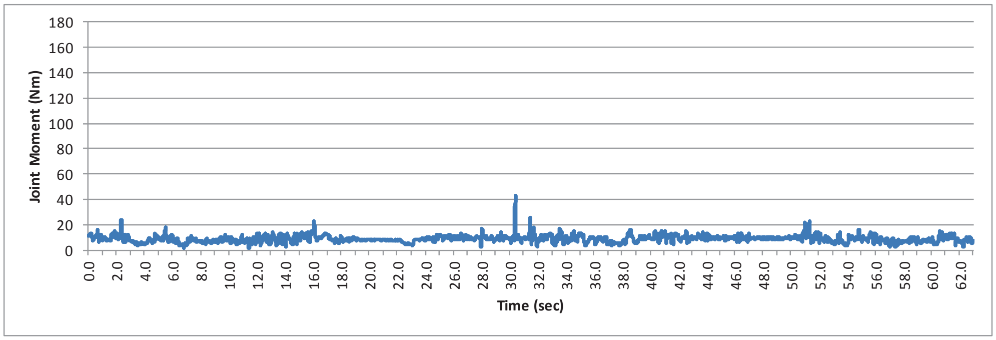
Posture Duration:	66.467	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

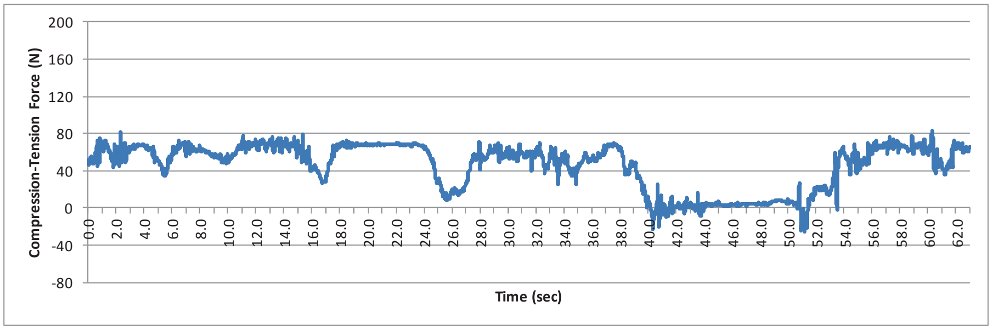
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	84.64	46.73	3001.18	Right Lateral Bend	30.44	12.94
Tension (N)	-24.82	-7.47	-16.77	Left Lateral Bend	-29.91	-13.46
Anterior Shear (N)	158.89	37.90	895.61	Left Axial Rotation	34.26	15.51
Posterior Shear (N)	-125.58	-31.33	-1342.24	Right Axial Rotation	-60.16	-25.89
Right Lateral Shear (N)	137.53	28.15	1000.26	Extension	26.96	8.80
Left Lateral Shear (N)	-96.99	-16.52	-511.23	Flexion	-51.59	-19.52
Torque (Resultant) (Nm)	10.88	8.46	187.55			
Right Lateral Moment (+Mx) (Nm	16.92	3.74	124.49			
Left Lateral Moment (-Mx) (Nm)	-12.46	-3.12	-103.31			
Left Axial Moment (+My) (Nm)	8.92	1.22	33.45			
Right Axial Moment (-My) (Nm)	-12.34	-2.85	-111.32			
Extension Moment (+Mz) (Nm)	16.99	6.35	316.16			
Flexion Moment (-Mz) (Nm)	-14.30	-4.99	-83.38			

Sling Hook-up Manual - Night

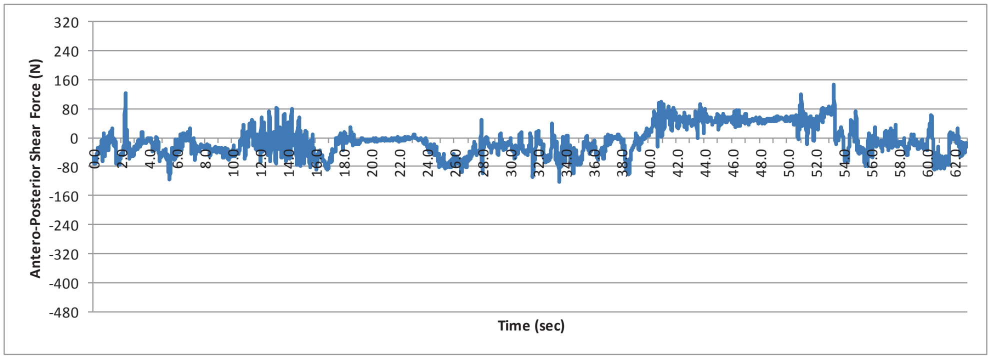
Resultant Neck Torque:



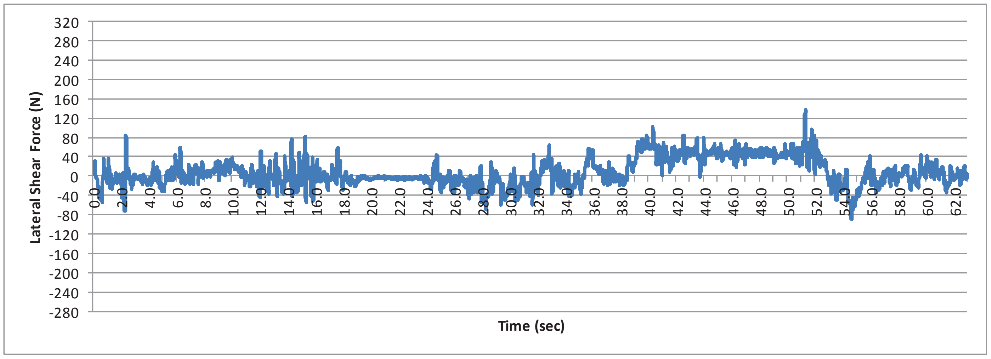
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



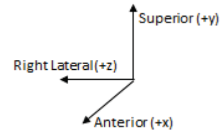
Lateral Shear (R+, L-):



Sling Unhook Manual - Day

Griffon MFTA - PDA: Postural Sequence

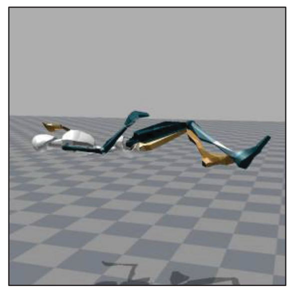
Postural Sequence:	Sling Unhook Manual (FE)
DAY	
Participant # (Sample Graphs):	FE02
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
FE egresses AC and crawls under the AC below cabin door and unhooks the sling eyelet from the AC hook. The sling is unhooked from the load, bundled and placed back into the AC. The FE then ingresses the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) 20' Sling

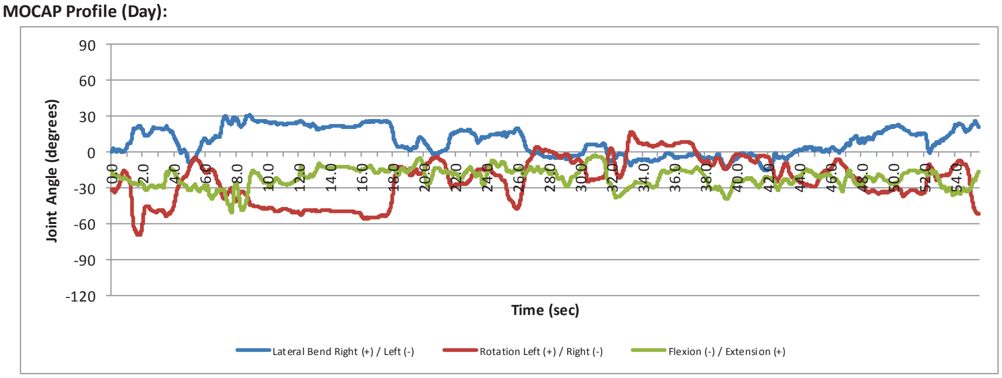
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



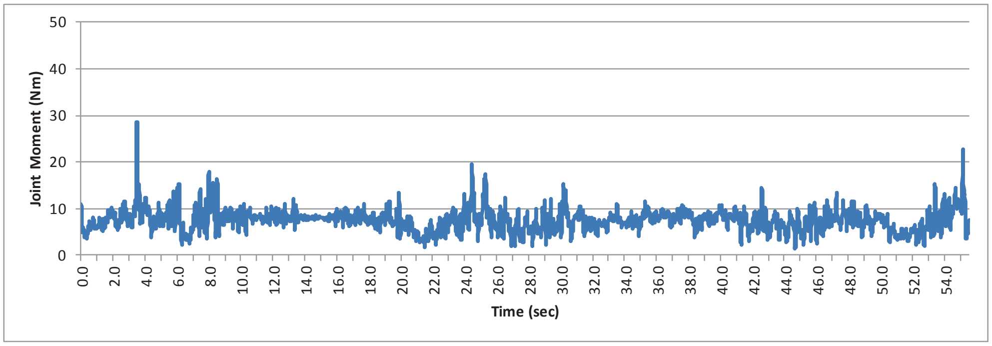
Posture Duration:	62.398	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

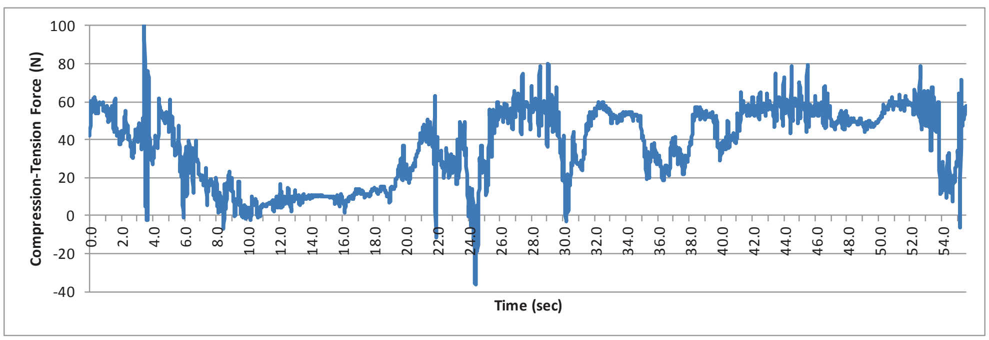
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	82.06	37.45	2125.60	Right Lateral Bend	29.65	11.93
Tension (N)	-41.43	-5.26	-29.74	Left Lateral Bend	-25.58	-11.30
Anterior Shear (N)	156.70	38.36	1041.79	Left Axial Rotation	37.17	17.95
Posterior Shear (N)	-129.01	-29.79	-1050.10	Right Axial Rotation	-64.51	-24.41
Right Lateral Shear (N)	114.75	22.58	827.54	Extension	25.75	13.96
Left Lateral Shear (N)	-100.92	-19.46	-501.40	Flexion	-49.37	-18.65
Torque (Resultant) (Nm)	28.01	7.25	376.84			
Right Lateral Moment (+Mx) (Nm)	13.93	2.89	86.51			
Left Lateral Moment (-Mx) (Nm)	-12.82	-2.69	-87.25			
Left Axial Moment (+My) (Nm)	8.68	1.37	31.14			
Right Axial Moment (-My) (Nm)	-9.46	-2.03	-80.43			
Extension Moment (+Mz) (Nm)	16.21	5.25	216.33			
Flexion Moment (-Mz) (Nm)	-19.17	-5.33	-113.00			

Sling Unhook Manual - Day

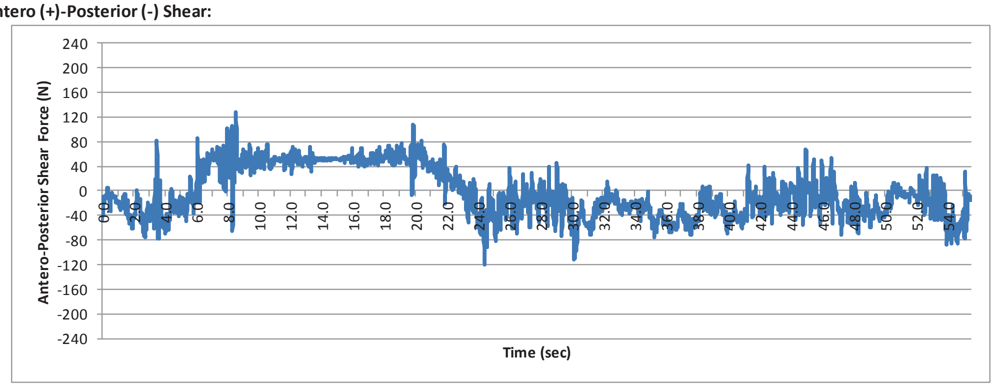
Resultant Neck Torque:



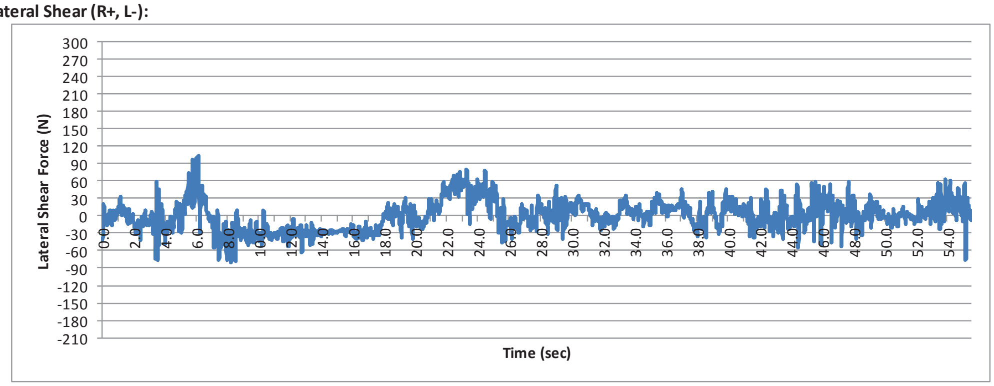
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



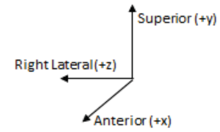
Lateral Shear (R+, L-):



Sling Unhook Manual – Night

Griffon MFTA - PDA: Postural Sequence

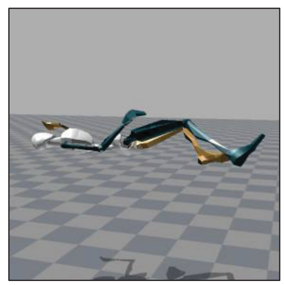
Postural Sequence:	Sling Unhook Manual (FE)
NIGHT	
Participant # (Sample Graphs):	FE02
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
FE egresses AC and crawls under the AC below cabin door and unhooks the sling eyelet from the AC hook. The sling is unhooked from the load, bundled and placed back into the AC. The FE then ingresses the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) 20' Sling

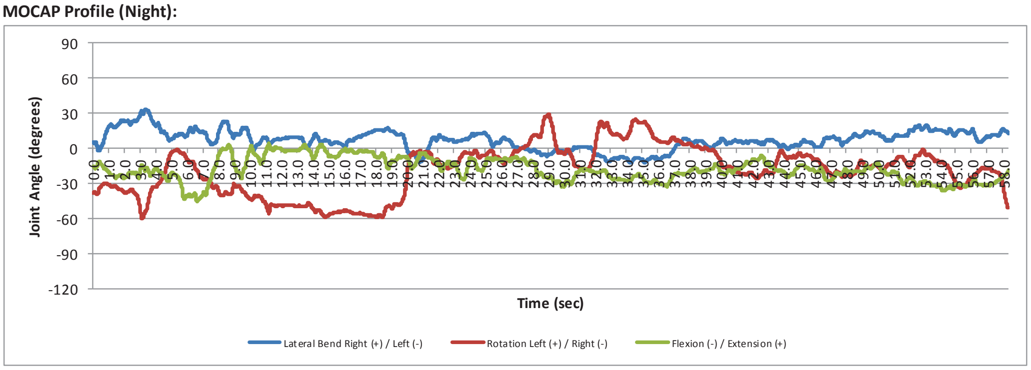
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



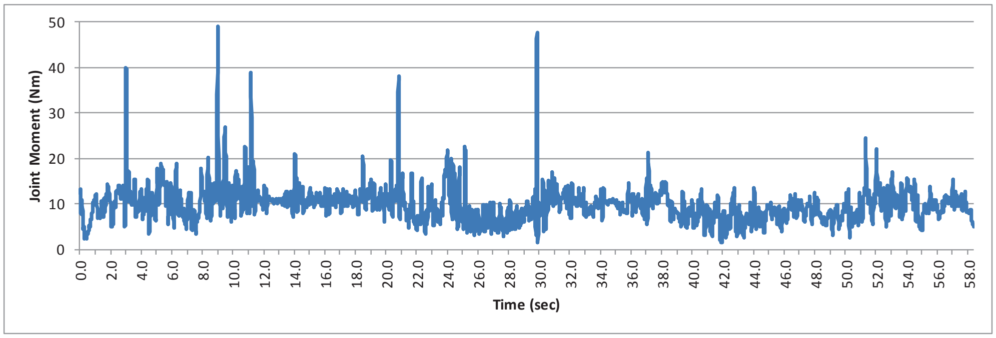
Posture Duration:	60.476	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

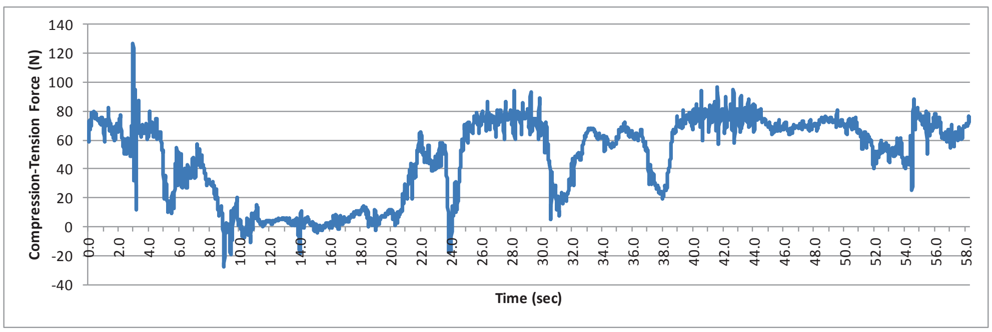
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	104.72	48.78	2674.48	Right Lateral Bend	25.02	8.37
Tension (N)	-33.70	-9.57	-54.16	Left Lateral Bend	-23.56	-7.77
Anterior Shear (N)	166.51	45.15	1085.33	Left Axial Rotation	50.45	22.61
Posterior Shear (N)	-155.00	-36.10	-1315.79	Right Axial Rotation	-42.69	-16.59
Right Lateral Shear (N)	147.04	27.18	926.68	Extension	17.77	7.31
Left Lateral Shear (N)	-140.03	-24.85	-655.64	Flexion	-46.29	-18.09
Torque (Resultant) (Nm)	36.78	9.13	552.13			
Right Lateral Moment (+Mx) (Nm	19.41	3.77	117.12			
Left Lateral Moment (-Mx) (Nm)	-18.49	-3.44	-101.22			
Left Axial Moment (+My) (Nm)	8.74	1.28	34.23			
Right Axial Moment (-My) (Nm)	-9.96	-1.58	-53.12			
Extension Moment (+Mz) (Nm)	20.98	6.68	281.61			
Flexion Moment (-Mz) (Nm)	-21.03	-6.98	-127.87			

Sling Unhook Manual - Night

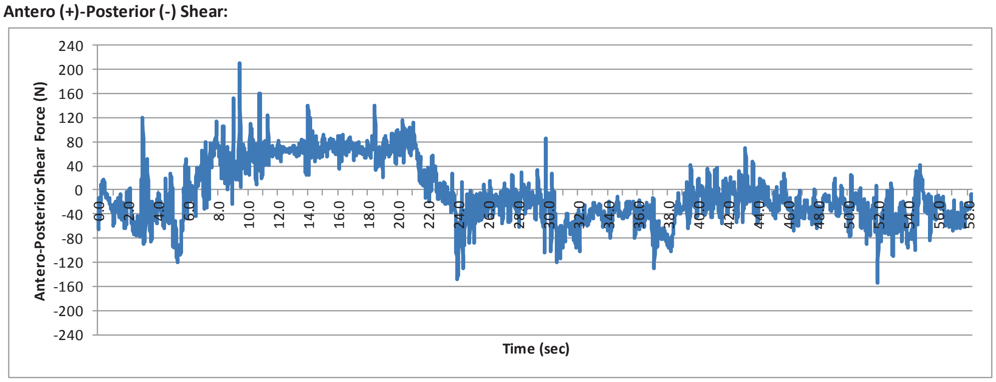
Resultant Neck Torque:



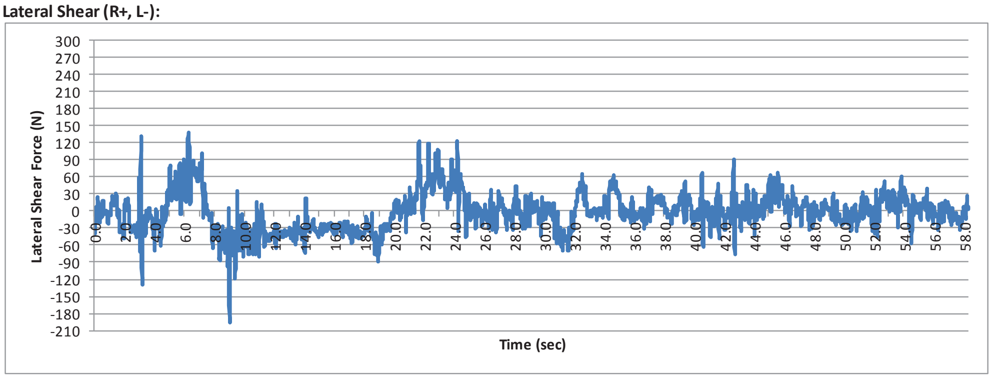
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



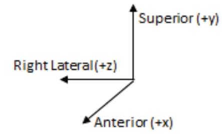
Lateral Shear (R+, L-):



Start-up Last Chance Inspection – Day

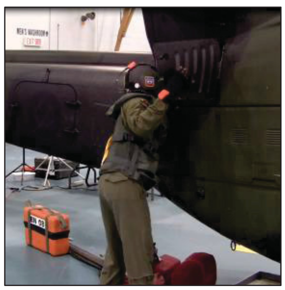
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Start-up/Last Chance Insp. (FE)
DAY	
Participant # (Sample Graphs):	FE03
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
At the front of the aircraft, the FE signals to the pilot to start up engine, the FE then initiates last chance inspection on the FP side of the aircraft checking for leaks, unsecured items, etc. Once finished the FE returns to the front signalling OK.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Flashlight

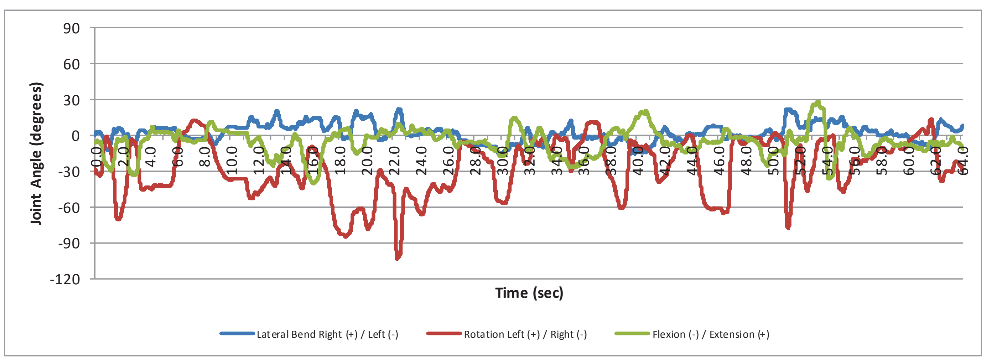
Image:



Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



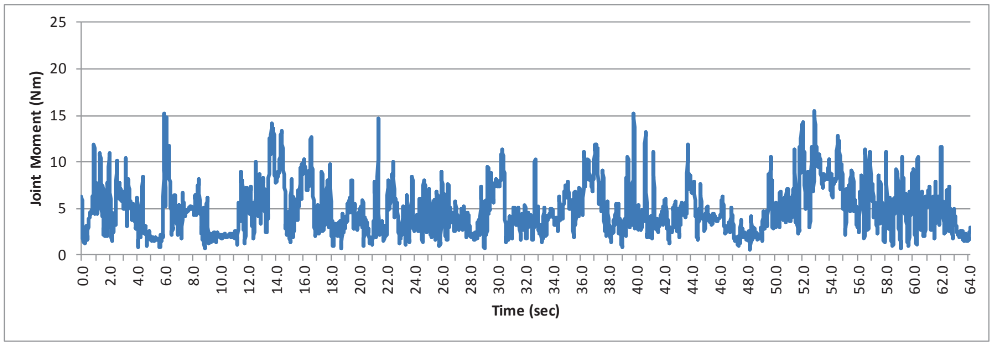
Posture Duration:	66.790	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

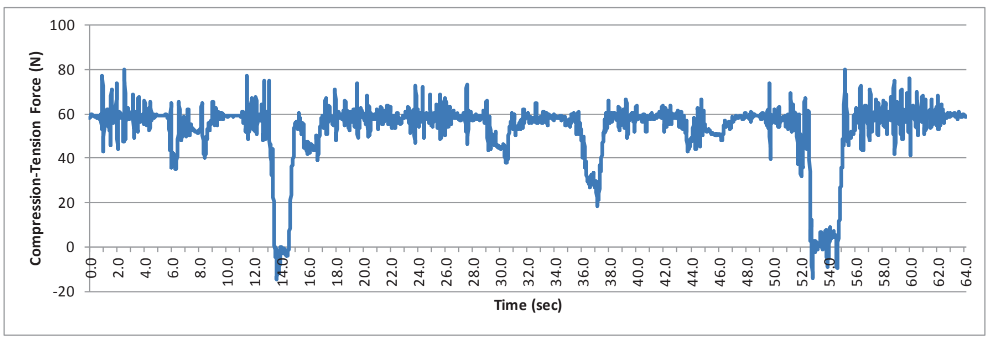
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	71.38	55.09	3656.18	Right Lateral Bend	22.09	7.28
Tension (N)	-7.94	-4.31	-3.70	Left Lateral Bend	-12.53	-6.03
Anterior Shear (N)	47.24	7.69	170.69	Left Axial Rotation	22.39	12.47
Posterior Shear (N)	-83.17	-16.69	-744.44	Right Axial Rotation	-58.60	-23.31
Right Lateral Shear (N)	61.00	12.10	466.24	Extension	14.91	5.18
Left Lateral Shear (N)	-62.73	-12.02	-339.77	Flexion	-41.72	-14.24
Torque (Resultant) (Nm)	9.02	4.45	198.14			
Right Lateral Moment (+Mx) (Nm)	7.26	1.71	62.01			
Left Lateral Moment (-Mx) (Nm)	-8.47	-1.84	-56.34			
Left Axial Moment (+My) (Nm)	3.74	0.61	15.66			
Right Axial Moment (-My) (Nm)	-5.47	-0.74	-30.43			
Extension Moment (+Mz) (Nm)	11.77	3.43	203.49			
Flexion Moment (-Mz) (Nm)	-4.87	-1.20	-9.07			

Start-up Last Chance Inspection – Day

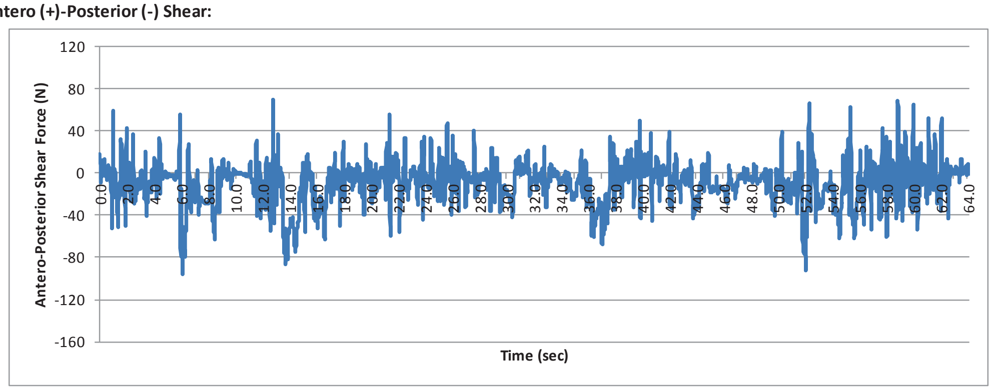
Resultant Neck Torque:



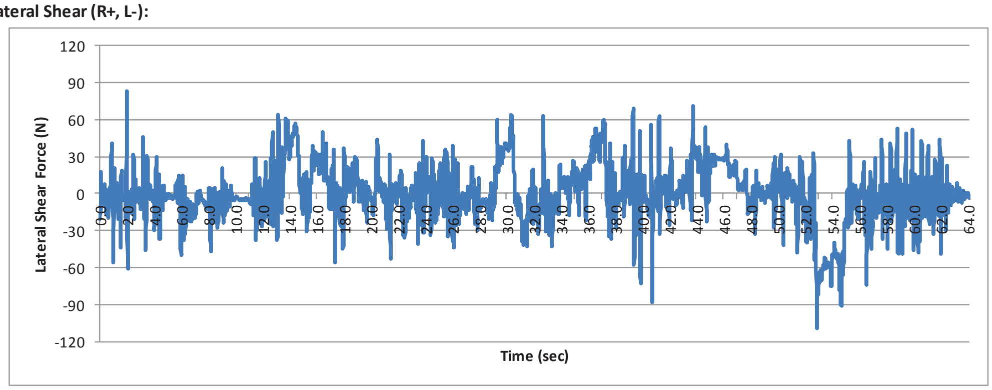
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



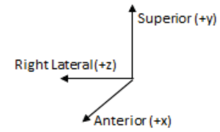
Lateral Shear (R+, L-):



Start-up Last Chance Inspection – Night

Griffon MFTA - PDA: Postural Sequence

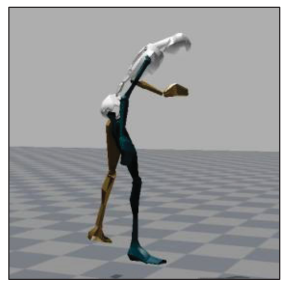
Postural Sequence:	Start-up/Last Chance Insp. (FE)
NIGHT	
Participant # (Sample Graphs):	FE03
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
At the front of the aircraft, the FE signals to the pilot to start up engine, the FE then initiates last chance inspection on the FP side of the aircraft checking for leaks, unsecured items, etc. Once finished the FE returns to the front signalling OK.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Flashlight

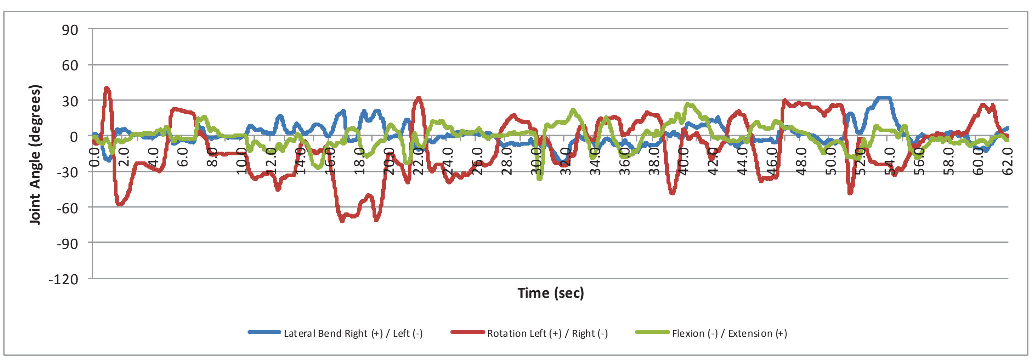
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	68.494	seconds

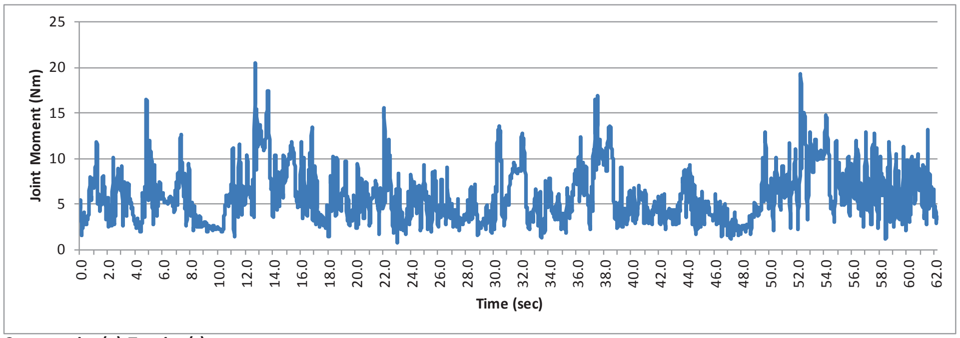
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	91.51	70.82	4842.11
Tension (N)	-3.89	-1.64	-0.85
Anterior Shear (N)	67.83	9.85	260.47
Posterior Shear (N)	-99.21	-20.22	-850.24
Right Lateral Shear (N)	69.66	14.33	605.44
Left Lateral Shear (N)	-79.45	-13.18	-346.10
Torque (Resultant) (Nm)	13.05	5.76	262.91
Right Lateral Moment (+Mx) (Nm	10.92	2.29	88.94
Left Lateral Moment (-Mx) (Nm)	-12.92	-2.35	-69.80
Left Axial Moment (+My) (Nm)	4.68	0.69	19.75
Right Axial Moment (-My) (Nm)	-6.07	-0.73	-29.14
Extension Moment (+Mz) (Nm)	16.31	4.56	259.06
Flexion Moment (-Mz) (Nm)	-7.89	-1.73	-20.10

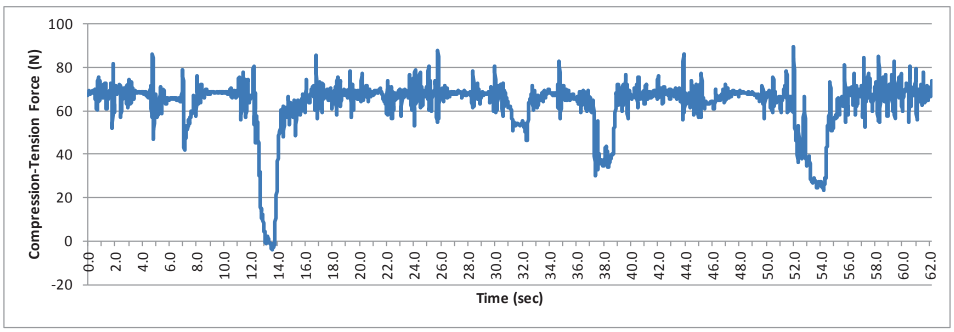
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	24.40	6.78
Left Lateral Bend	-19.03	-4.88
Left Axial Rotation	36.03	13.95
Right Axial Rotation	-43.62	-17.17
Extension	15.53	5.90
Flexion	-43.08	-14.26

Start-up Last Chance Inspection – Night

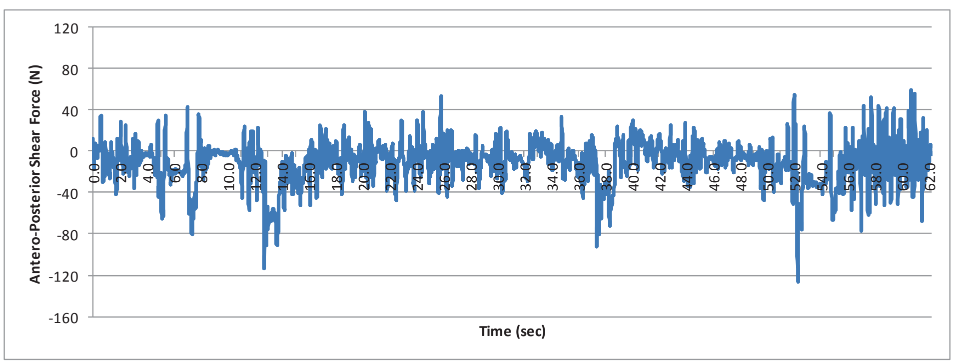
Resultant Neck Torque:



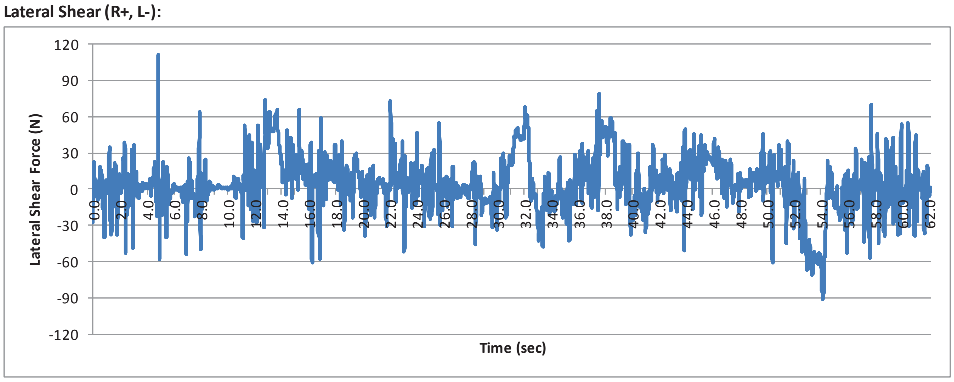
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



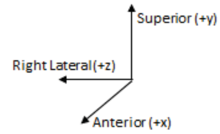
Lateral Shear (R+, L-):



Transit Seated - Day

Griffon MFTA - PDA: Postural Sequence

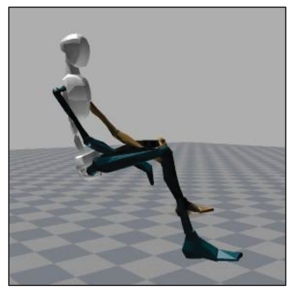
Postural Sequence:	Transit Seated (FE)
DAY	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
Seated on the jump seat facing forward, the FE performs personal tasks while transiting at altitude.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

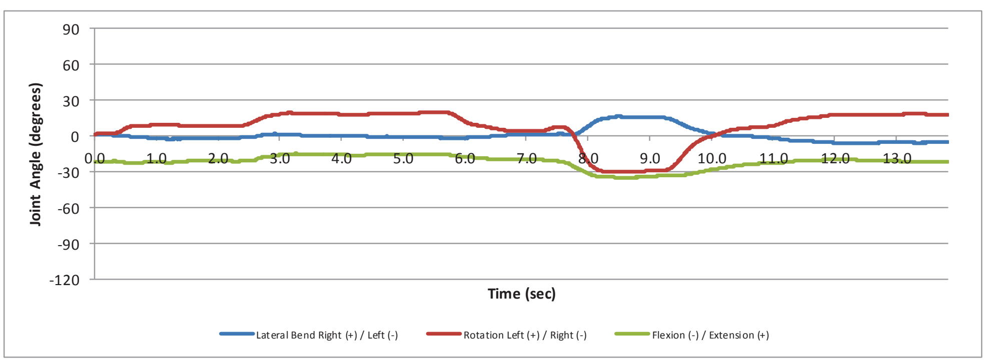
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	11.215	seconds

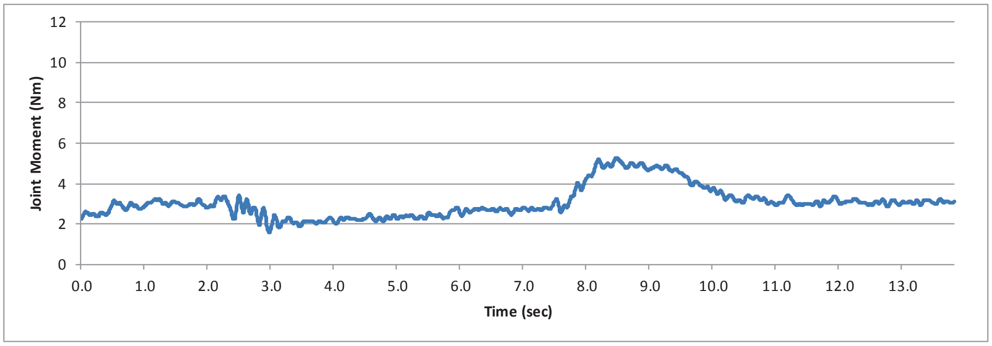
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	60.50	58.63	658.02
Tension (N)	NA	NA	NA
Anterior Shear (N)	7.20	5.02	35.39
Posterior Shear (N)	-25.00	-9.37	-65.18
Right Lateral Shear (N)	6.94	2.56	11.20
Left Lateral Shear (N)	-6.68	-3.07	-21.04
Torque (Resultant) (Nm)	4.02	2.58	24.15
Right Lateral Moment (+Mx) (Nm)	1.06	0.42	2.58
Left Lateral Moment (-Mx) (Nm)	-1.99	-1.12	-5.65
Left Axial Moment (+My) (Nm)	0.52	0.12	0.53
Right Axial Moment (-My) (Nm)	-0.45	-0.13	-0.86
Extension Moment (+Mz) (Nm)	4.39	2.21	24.73
Flexion Moment (-Mz) (Nm)	-0.81	-0.34	-0.04

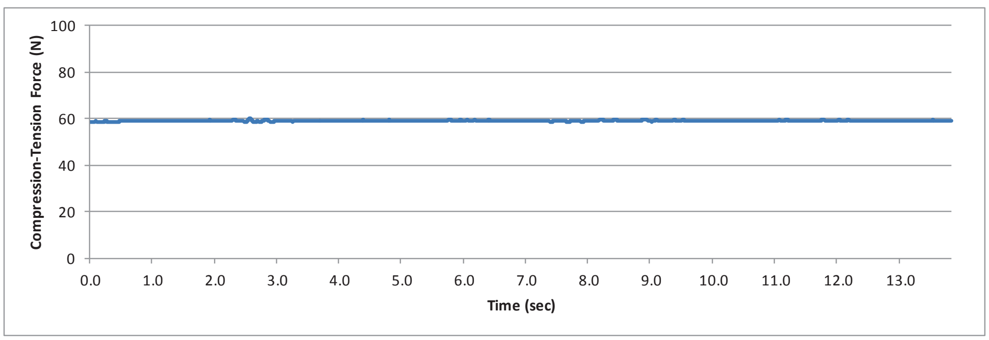
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	9.13	3.99
Left Lateral Bend	-5.23	-2.04
Left Axial Rotation	19.63	11.04
Right Axial Rotation	-43.62	-23.97
Extension	6.23	3.24
Flexion	-22.05	-13.37

Transit Seated – Day

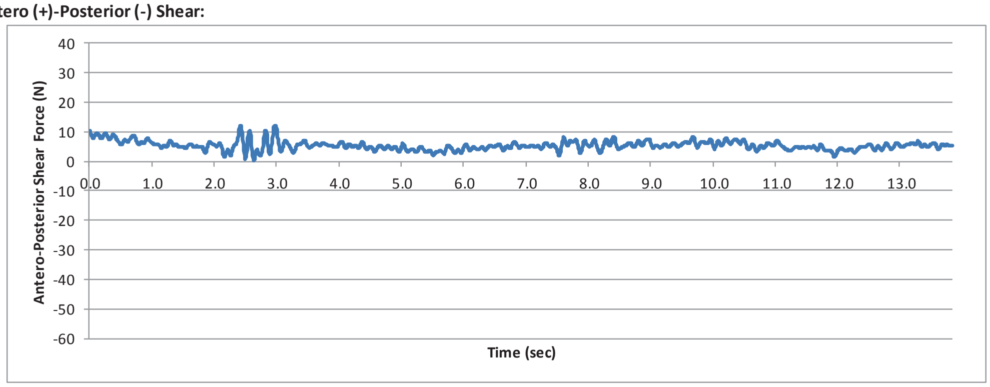
Resultant Neck Torque:



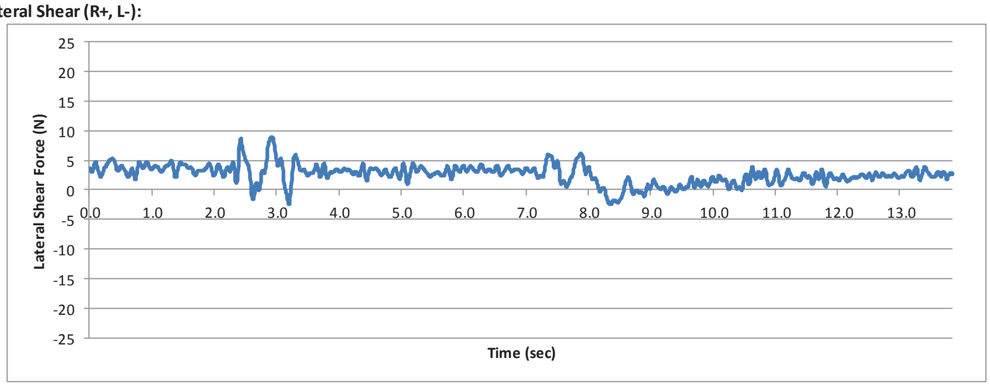
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



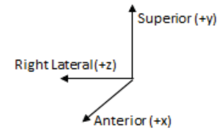
Lateral Shear (R+, L-):



Transit Seated - Night

Griffon MFTA - PDA: Postural Sequence

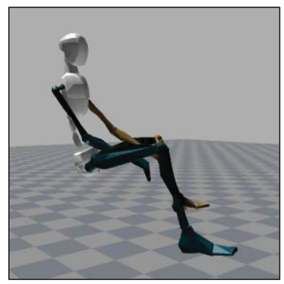
Postural Sequence:	Transit Seated (FE)
NIGHT	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
Seated on the jump seat facing forward, the FE performs personal tasks while transiting at altitude.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

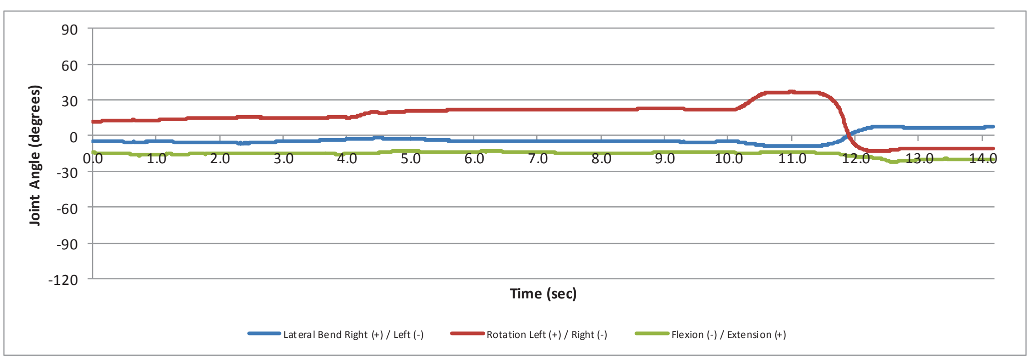
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



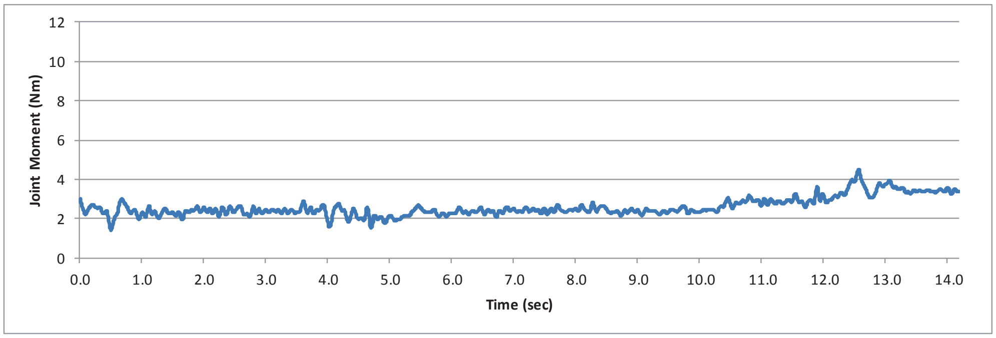
Posture Duration:	13.903	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

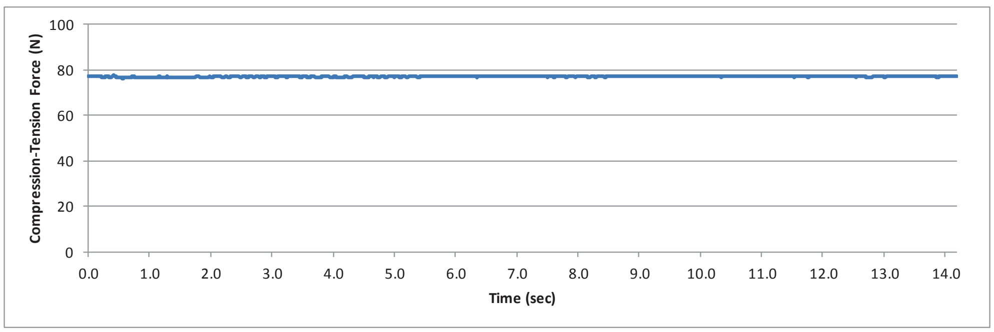
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	75.65	73.36	1020.60	Right Lateral Bend	13.21	7.29
Tension (N)	NA	NA	NA	Left Lateral Bend	-13.72	-6.25
Anterior Shear (N)	14.84	7.84	42.88	Left Axial Rotation	35.55	20.72
Posterior Shear (N)	-30.30	-7.95	-83.87	Right Axial Rotation	-61.95	-37.03
Right Lateral Shear (N)	13.05	2.69	19.04	Extension	6.94	5.07
Left Lateral Shear (N)	-13.16	-3.71	-25.37	Flexion	-20.50	-12.16
Torque (Resultant) (Nm)	5.52	3.61	41.91			
Right Lateral Moment (+Mx) (Nm	3.24	1.29	8.92			
Left Lateral Moment (-Mx) (Nm)	-4.34	-1.89	-13.24			
Left Axial Moment (+My) (Nm)	1.62	0.38	1.87			
Right Axial Moment (-My) (Nm)	-1.74	-0.24	-2.14			
Extension Moment (+Mz) (Nm)	5.50	2.94	38.49			
Flexion Moment (-Mz) (Nm)	-2.25	-0.61	-1.27			

Transit Seated - Night

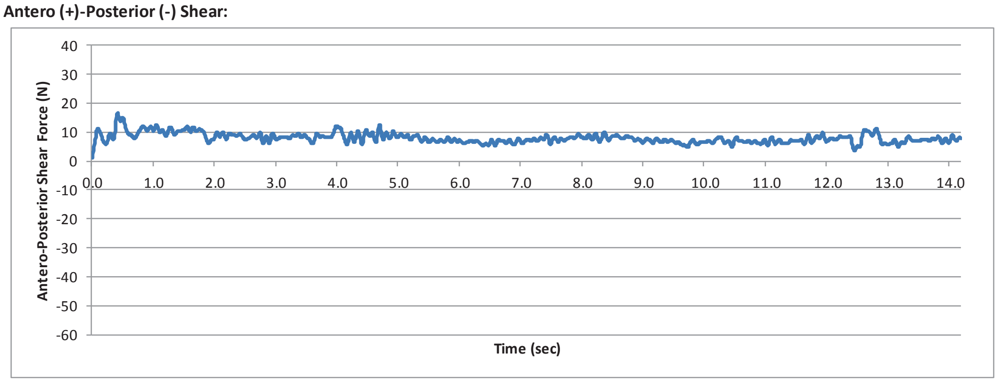
Resultant Neck Torque:



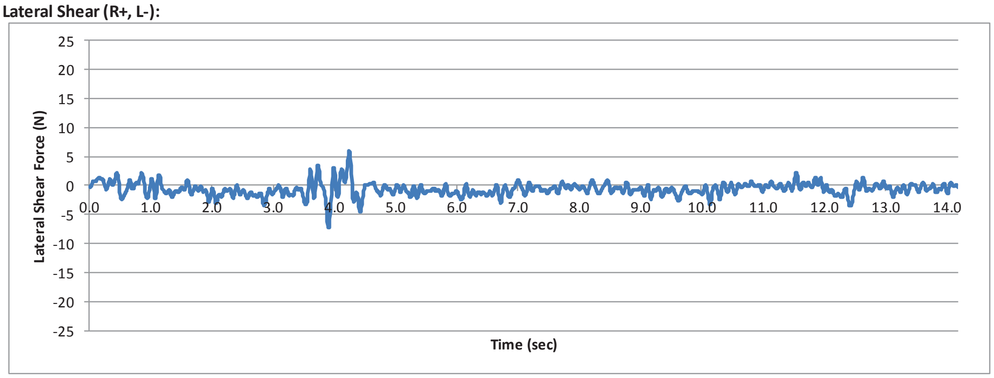
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



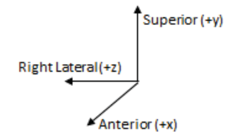
Lateral Shear (R+, L-):



Walking - Day

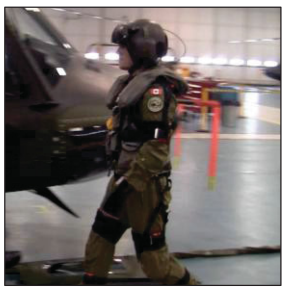
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Walking (FE)
DAY	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet Only

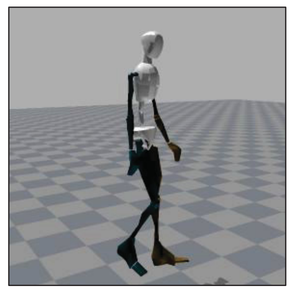


Task Description:	**Equipment Considerations:**
Depending on weather and preferences, FEs will wear their helmet from the hangar to AC, during troop loading, etc.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

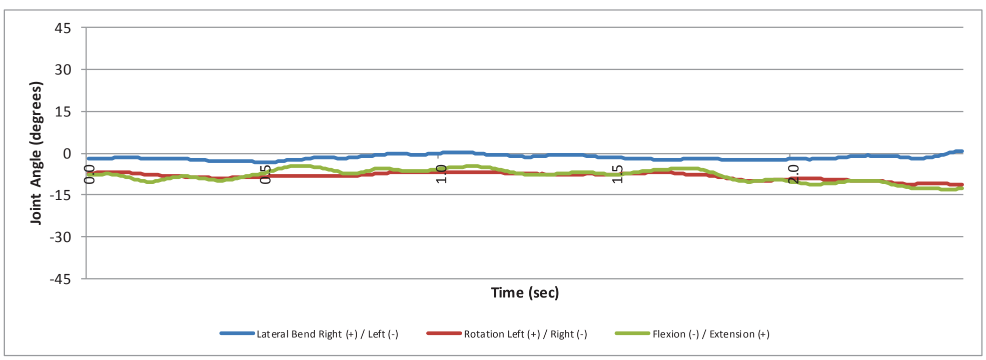


Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	3.025	seconds

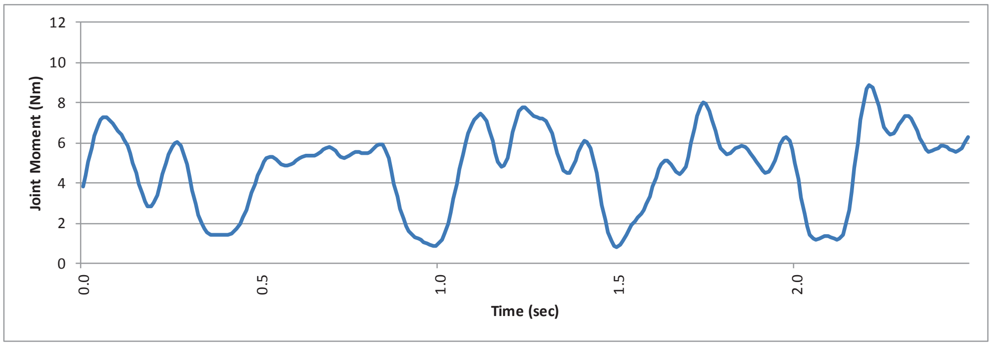
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	70.27	58.80	178.35
Tension (N)	NA	NA	NA
Anterior Shear (N)	35.43	11.26	11.54
Posterior Shear (N)	-36.62	-13.16	-26.42
Right Lateral Shear (N)	35.46	8.52	12.90
Left Lateral Shear (N)	-33.63	-9.48	-14.40
Torque (Resultant) (Nm)	5.18	3.92	7.92
Right Lateral Moment (+Mx) (Nm)	4.33	1.26	1.11
Left Lateral Moment (-Mx) (Nm)	-4.98	-1.40	-3.01
Left Axial Moment (+My) (Nm)	1.28	0.35	0.48
Right Axial Moment (-My) (Nm)	-1.40	-0.36	-0.61
Extension Moment (+Mz) (Nm)	6.96	3.11	8.81
Flexion Moment (-Mz) (Nm)	-2.58	-1.89	-0.38

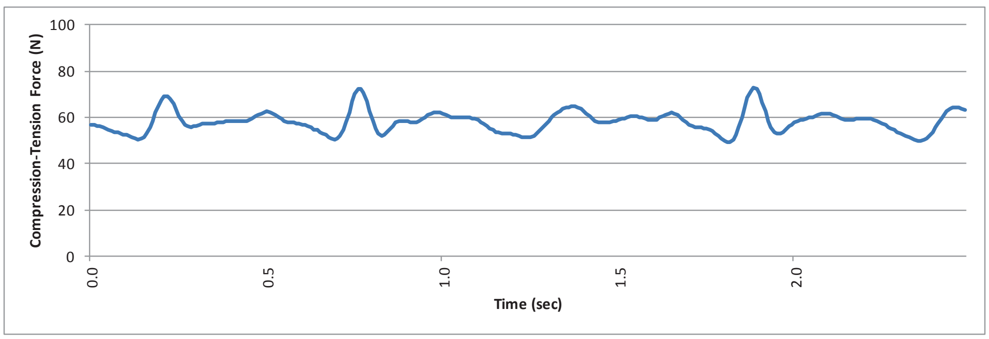
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	4.99	4.17
Left Lateral Bend	-1.44	-1.65
Left Axial Rotation	NA	NA
Right Axial Rotation	-16.60	-14.50
Extension	NA	NA
Flexion	-15.43	-11.51

Walking - Day

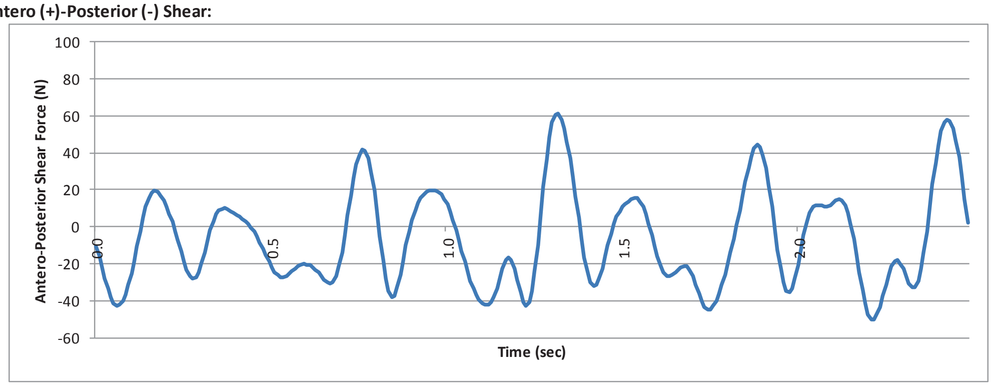
Resultant Neck Torque:



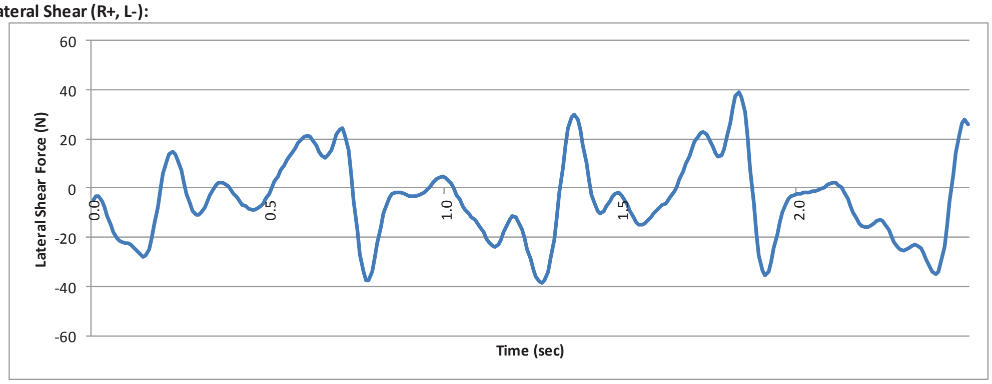
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



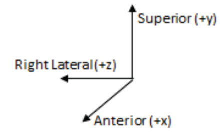
Lateral Shear (R+, L-):



Walking – Night

Griffon MFTA - PDA: Postural Sequence

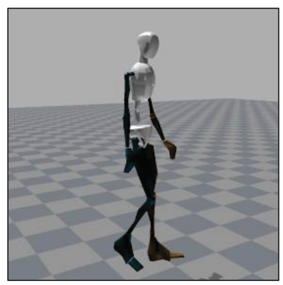
Postural Sequence:	Walking (FE)
NIGHT	
Participant # (Sample Graphs):	FE06
Role:	Flight Engineer
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
Depending on weather and preferences, FEs will wear their helmet from the hangar to AC, during troop loading, etc.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

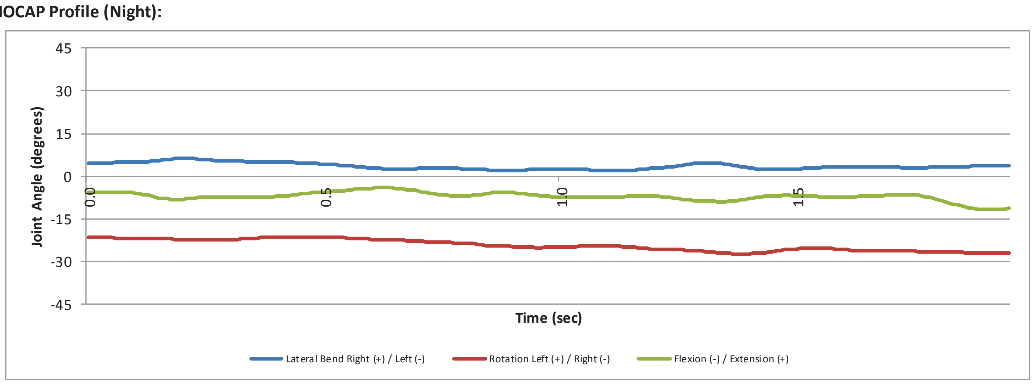
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



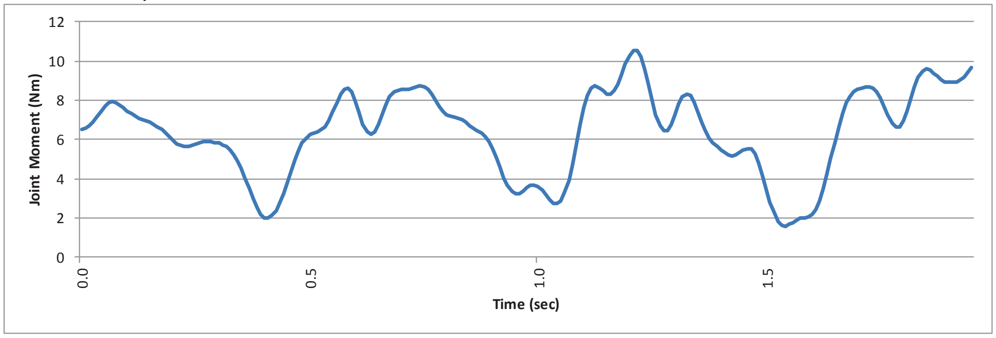
Posture Duration:	2.795	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

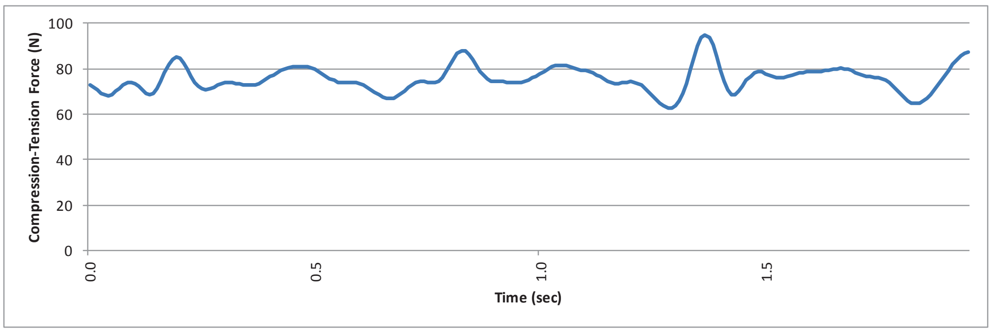
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	86.31	74.92	210.02	Right Lateral Bend	6.40	3.73
Tension (N)	NA	NA	NA	Left Lateral Bend	-4.51	-3.81
Anterior Shear (N)	46.81	12.03	11.65	Left Axial Rotation	15.81	11.44
Posterior Shear (N)	-41.57	-14.40	-26.42	Right Axial Rotation	-15.05	-16.87
Right Lateral Shear (N)	38.17	11.64	18.59	Extension	2.09	1.44
Left Lateral Shear (N)	-30.28	-10.59	-12.77	Flexion	-14.02	-9.49
Torque (Resultant) (Nm)	7.78	4.85	11.32			
Right Lateral Moment (+Mx) (Nm	5.19	1.72	2.51			
Left Lateral Moment (-Mx) (Nm)	-4.56	-1.87	-2.52			
Left Axial Moment (+My) (Nm)	1.45	0.35	0.42			
Right Axial Moment (-My) (Nm)	-1.35	-0.41	-0.67			
Extension Moment (+Mz) (Nm)	8.65	3.68	9.50			
Flexion Moment (-Mz) (Nm)	-4.43	-1.64	-0.46			

Walking - Night

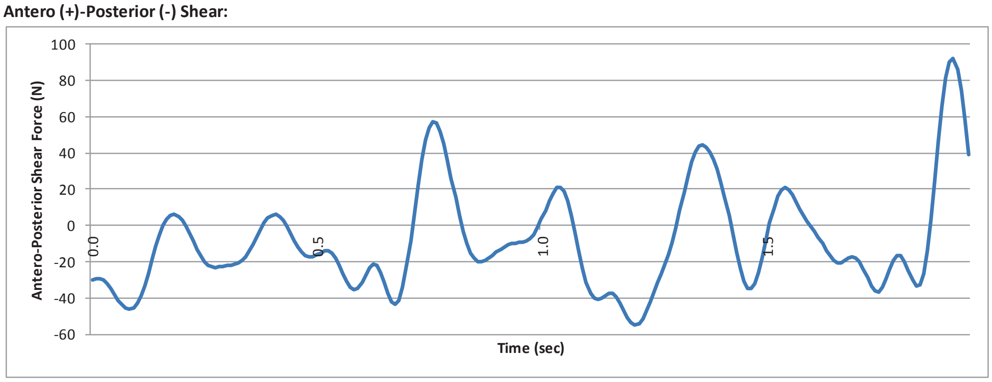
Resultant Neck Torque:



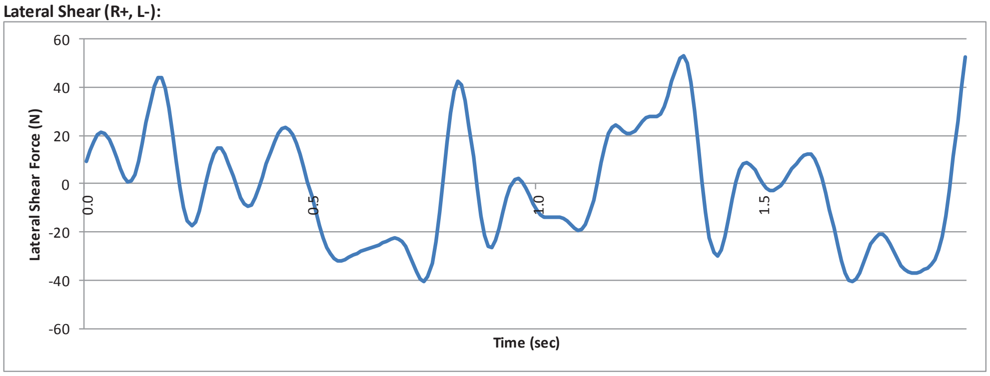
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):



Flying Pilot

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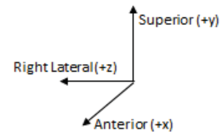
AC Egress - Day

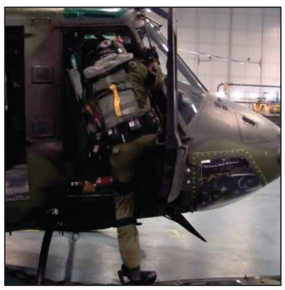
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	AC Egress (FP)
DAY	
Participant # (Sample Graphs):	FP07
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
The FP disconnects communications (and HUD if night mission), removes restraints and egresses the aircraft through the PF door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

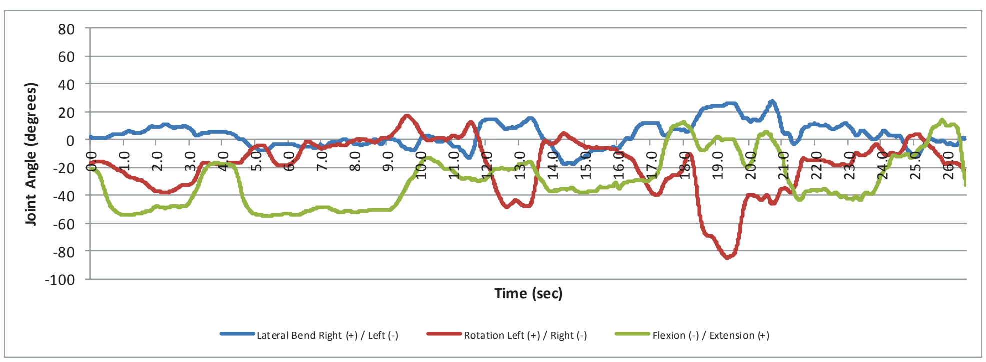
Image:



Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	25.027	seconds

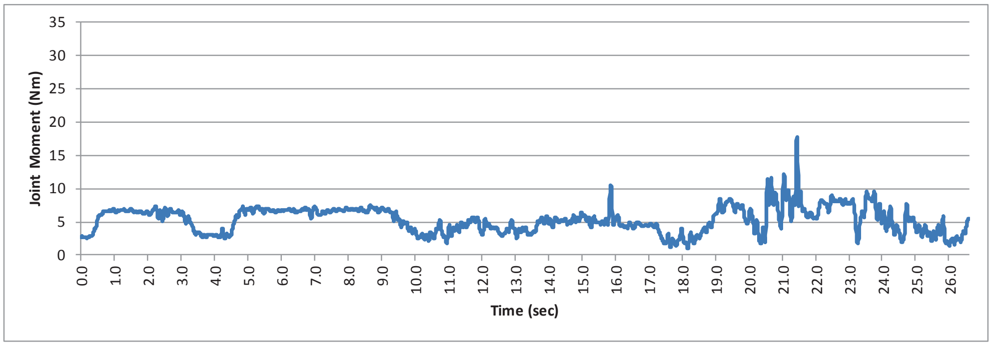
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	67.08	56.49	1414.27
Tension (N)	NA	NA	NA
Anterior Shear (N)	63.61	7.27	69.98
Posterior Shear (N)	-78.12	-14.37	-221.40
Right Lateral Shear (N)	53.73	9.25	110.14
Left Lateral Shear (N)	-56.05	-10.10	-132.62
Torque (Resultant) (Nm)	15.90	6.03	107.79
Right Lateral Moment (+Mx) (Nm)	7.05	1.65	20.23
Left Lateral Moment (-Mx) (Nm)	-6.54	-1.65	-21.03
Left Axial Moment (+My) (Nm)	5.36	0.91	12.22
Right Axial Moment (-My) (Nm)	-4.17	-0.71	-8.24
Extension Moment (+Mz) (Nm)	12.65	5.30	129.81
Flexion Moment (-Mz) (Nm)	-4.09	-1.32	-0.87

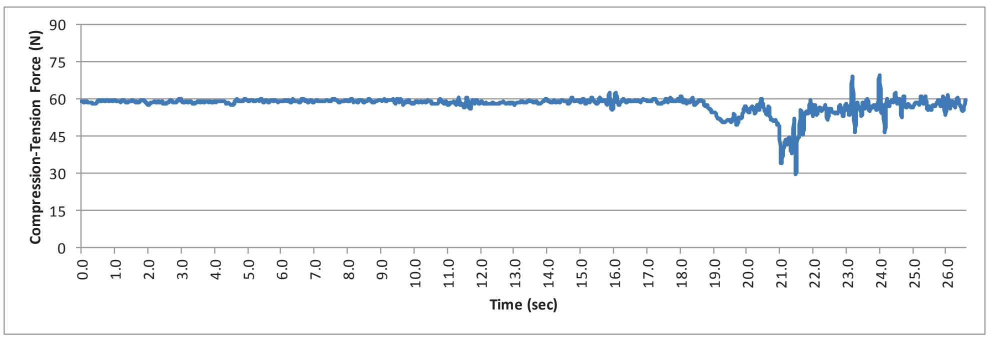
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	15.52	8.54
Left Lateral Bend	-17.52	-8.10
Left Axial Rotation	26.67	14.99
Right Axial Rotation	-42.44	-15.63
Extension	14.21	6.67
Flexion	-56.35	-34.45

AC Egress – Day

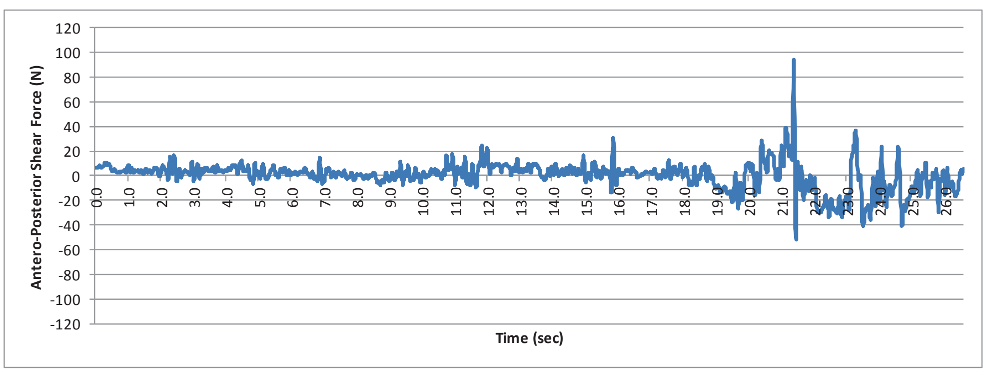
Resultant Neck Torque:



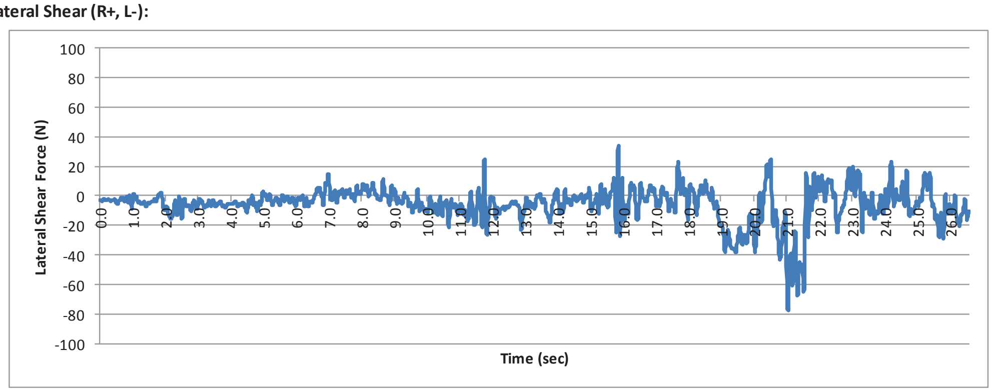
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



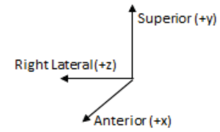
Lateral Shear (R+, L-):



AC Egress - Night

Griffon MFTA - PDA: Postural Sequence

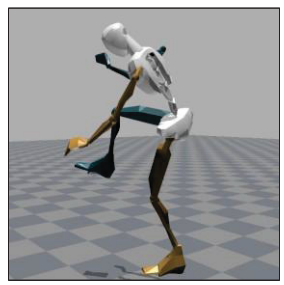
Postural Sequence:	AC Egress (FP)
NIGHT	
Participant # (Sample Graphs):	FP07
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
The FP disconnects communications (and HUD if night mission), removes restraints and egresses the aircraft through the PF door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

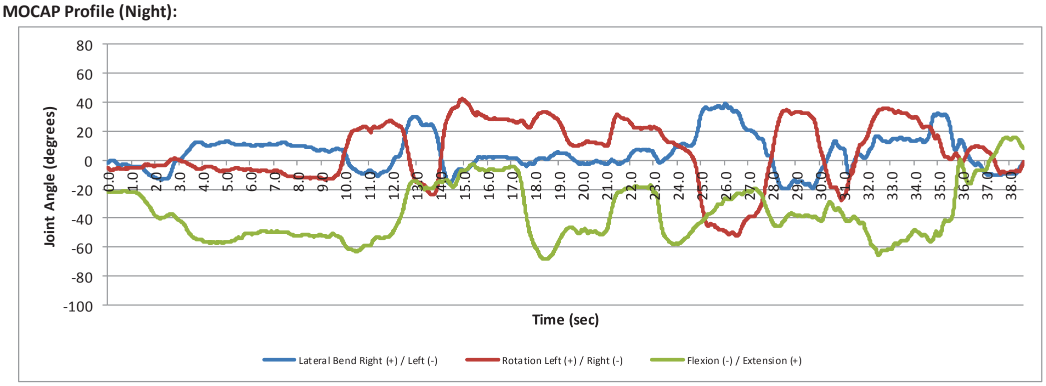
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	30.421	seconds

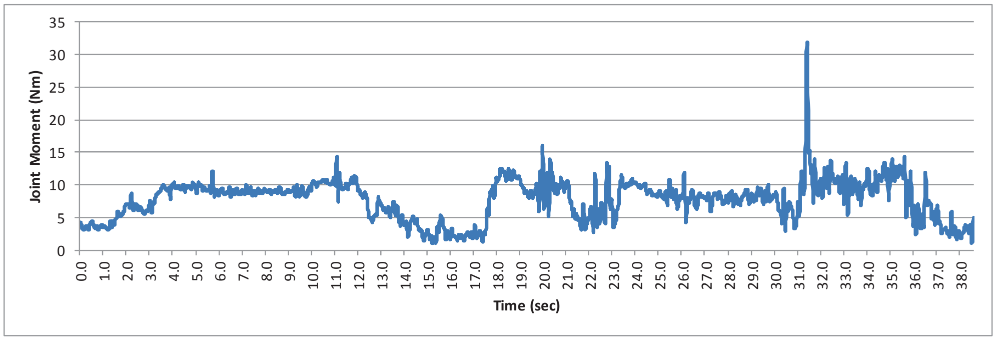
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	85.18	70.65	2149.67	Right Lateral Bend	23.95	9.75
Tension (N)	NA	NA	NA	Left Lateral Bend	-24.04	-9.78
Anterior Shear (N)	58.94	10.08	129.69	Left Axial Rotation	48.89	19.45
Posterior Shear (N)	-105.39	-21.09	-370.36	Right Axial Rotation	-34.30	-12.49
Right Lateral Shear (N)	76.73	12.35	187.68	Extension	10.75	10.26
Left Lateral Shear (N)	-61.96	-9.70	-147.68	Flexion	-52.32	-31.98
Torque (Resultant) (Nm)	13.81	7.84	136.32			
Right Lateral Moment (+Mx) (Nm	10.77	2.37	40.08			
Left Lateral Moment (-Mx) (Nm)	-8.15	-1.93	-26.01			
Left Axial Moment (+My) (Nm)	7.92	1.00	16.61			
Right Axial Moment (-My) (Nm)	-6.56	-1.19	-16.42			
Extension Moment (+Mz) (Nm)	16.24	7.06	200.76			
Flexion Moment (-Mz) (Nm)	-4.74	-1.78	-3.53			

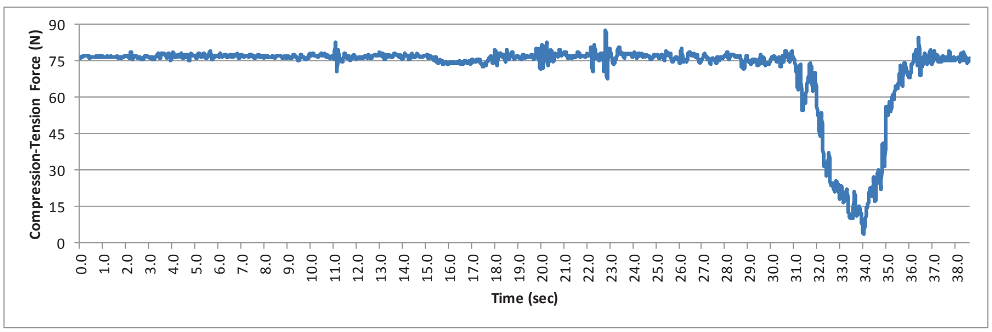
HUMANSYSTEMS Incorporated

AC Egress - Night

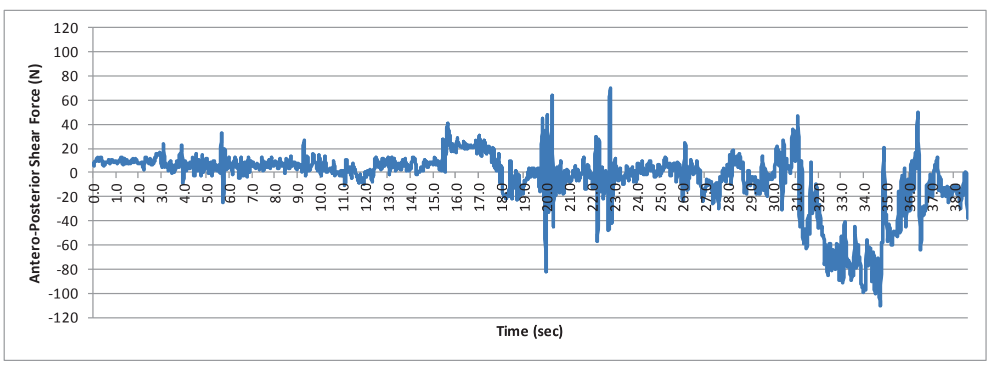
Resultant Neck Torque:



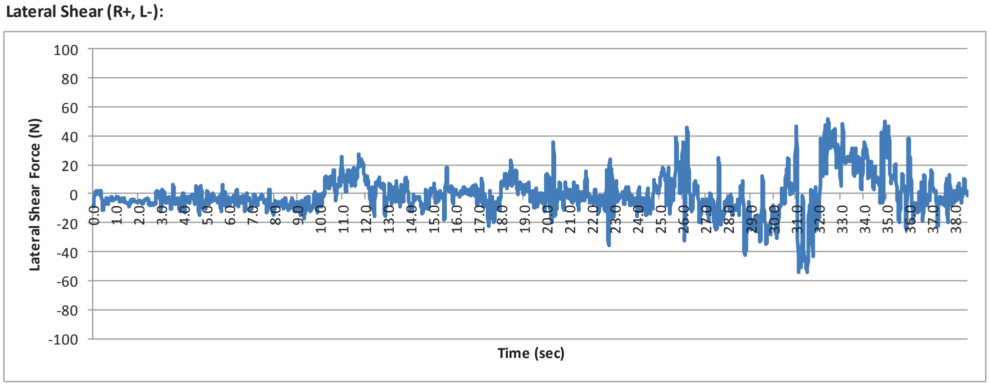
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



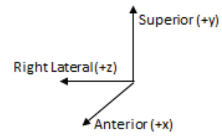
Lateral Shear (R+, L-):



AC Ingress - Day

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	AC Ingress (FP)
DAY	
Participant # (Sample Graphs):	FP06
Role:	Flying Pilot
Helmet Condition:	Helmet Only



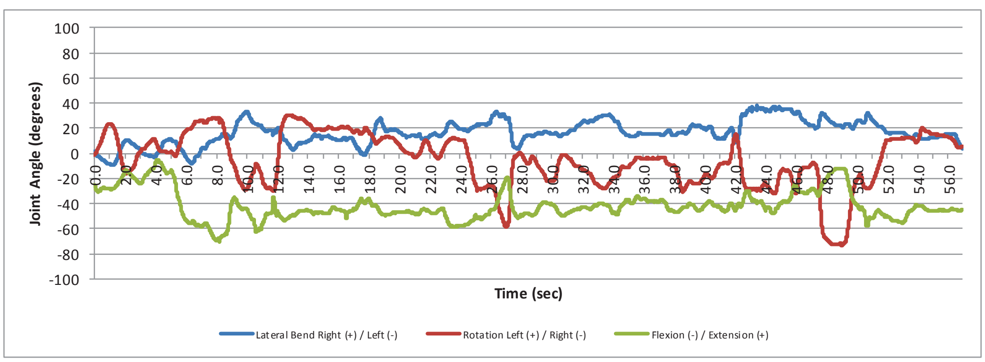
Task Description:	Equipment Considerations:
The FP opens the FP door of the AC, steps up into seat, adjusts seat and restraints, and finally connects communications. HUD is connected for night missions.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



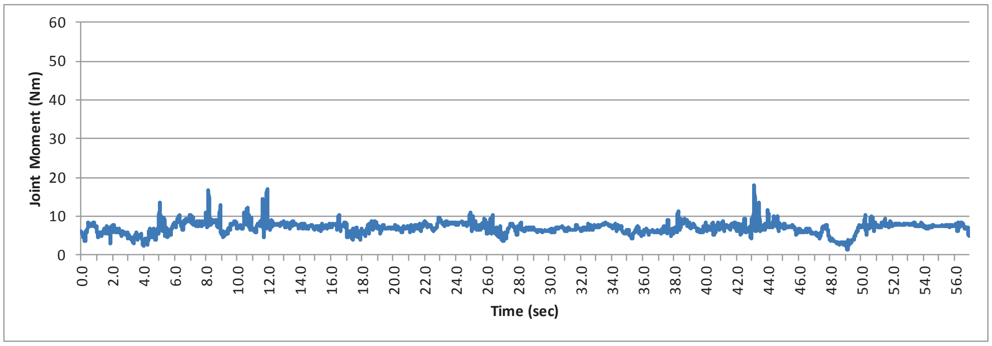
Posture Duration:	57.144	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

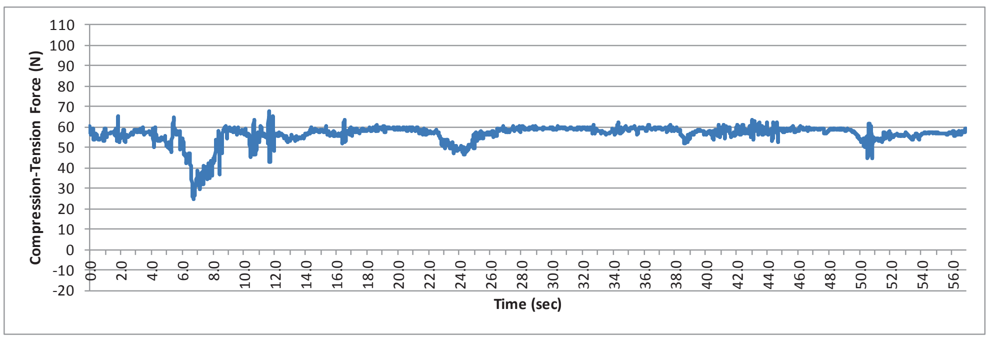
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	69.18	56.87	3244.66	Right Lateral Bend	26.85	10.83
Tension (N)	-20.61	-8.75	-3.36	Left Lateral Bend	-16.54	-6.59
Anterior Shear (N)	47.36	9.08	188.58	Left Axial Rotation	33.95	11.27
Posterior Shear (N)	-84.74	-12.74	-463.57	Right Axial Rotation	-64.99	-22.13
Right Lateral Shear (N)	61.35	8.90	252.11	Extension	9.37	7.10
Left Lateral Shear (N)	-76.59	-8.75	-252.10	Flexion	-65.06	-38.71
Torque (Resultant) (Nm)	17.19	6.22	203.10			
Right Lateral Moment (+Mx) (Nm)	7.06	1.36	27.84			
Left Lateral Moment (-Mx) (Nm)	-8.49	-1.94	-71.20			
Left Axial Moment (+My) (Nm)	8.66	0.83	21.82			
Right Axial Moment (-My) (Nm)	-6.38	-0.90	-27.97			
Extension Moment (+Mz) (Nm)	13.20	5.43	305.09			
Flexion Moment (-Mz) (Nm)	-3.58	-1.45	-1.92			

AC Ingress – Day

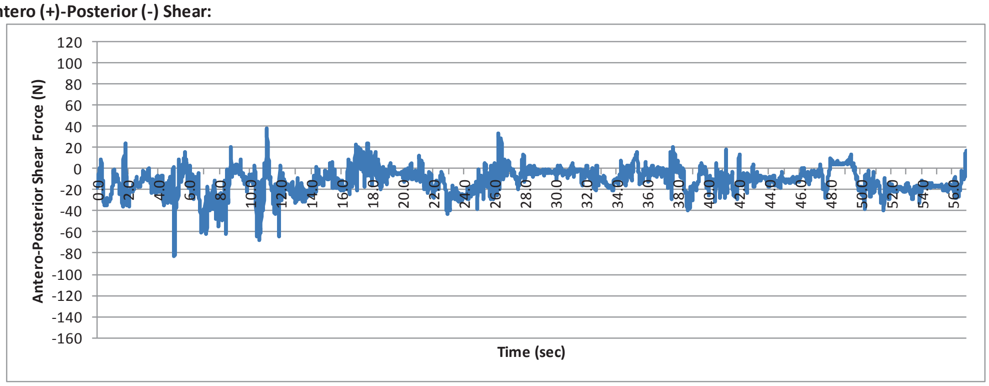
Resultant Neck Torque:



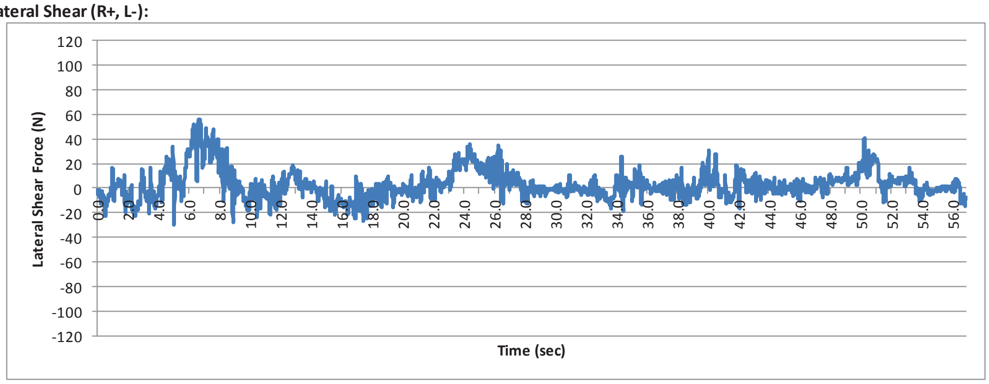
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



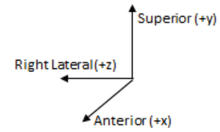
Lateral Shear (R+, L-):



AC Ingress - Night

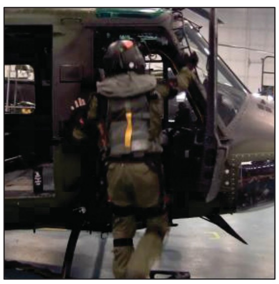
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	AC Ingress (FP)
NIGHT	
Participant # (Sample Graphs):	FP06
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
The FP opens the FP door of the AC, steps up into seat, adjusts seat and restraints, and finally connects communications. HUD is connected for night missions.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

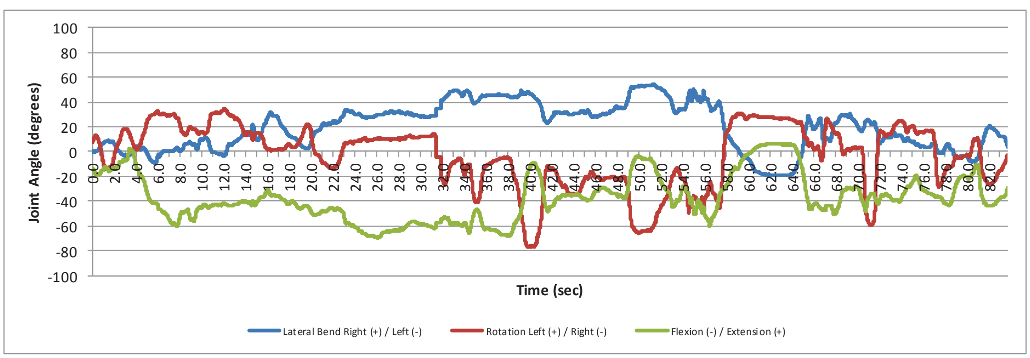
Image:



Photograph

MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	82.211	seconds

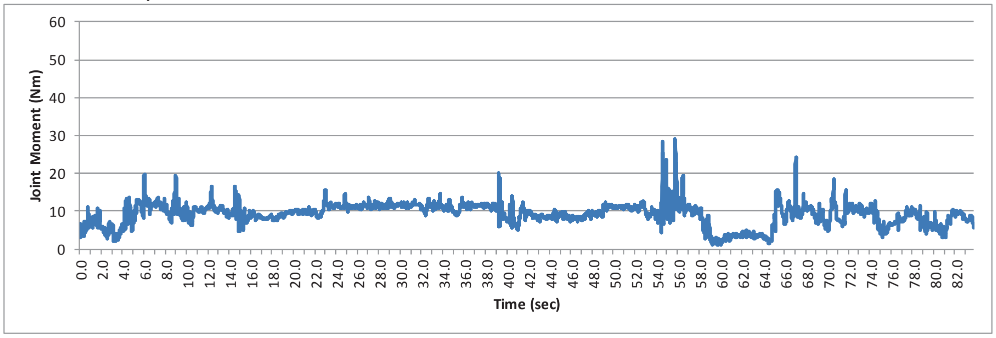
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	96.05	70.27	5771.74
Tension (N)	-14.15	-8.81	-2.13
Anterior Shear (N)	76.07	9.57	320.18
Posterior Shear (N)	-120.29	-19.64	-957.73
Right Lateral Shear (N)	94.96	14.07	619.67
Left Lateral Shear (N)	-82.99	-10.12	-386.54
Torque (Resultant) (Nm)	16.05	8.23	290.01
Right Lateral Moment (+Mx) (Nm	10.95	2.52	103.53
Left Lateral Moment (-Mx) (Nm)	-14.36	-3.57	-147.10
Left Axial Moment (+My) (Nm)	10.28	1.10	40.55
Right Axial Moment (-My) (Nm)	-10.89	-1.77	-80.01
Extension Moment (+Mz) (Nm)	17.62	6.82	521.68
Flexion Moment (-Mz) (Nm)	-4.16	-1.90	-10.83

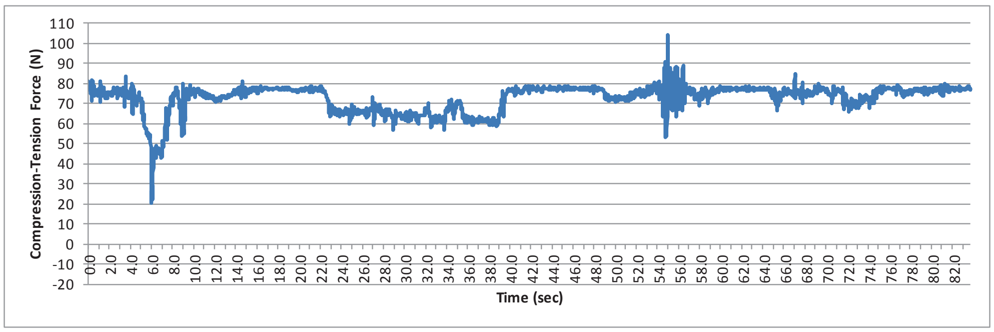
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	37.17	19.17
Left Lateral Bend	-28.42	-12.76
Left Axial Rotation	48.54	21.17
Right Axial Rotation	-62.22	-20.96
Extension	8.81	5.72
Flexion	-67.75	-35.66

AC Ingress - Night

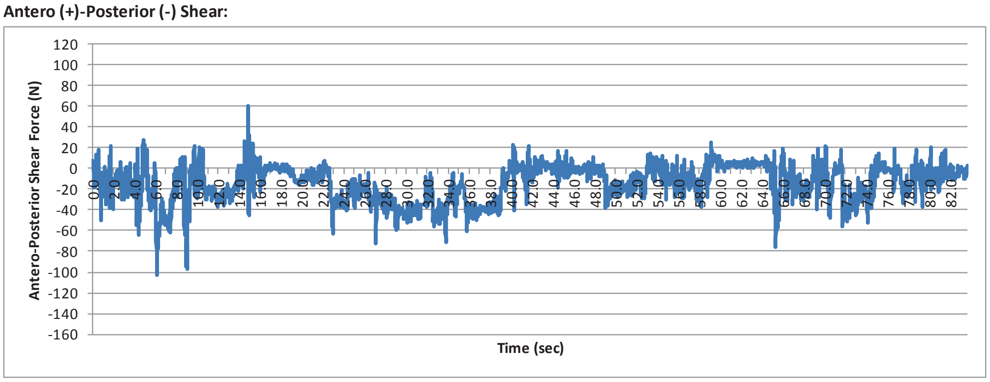
Resultant Neck Torque:



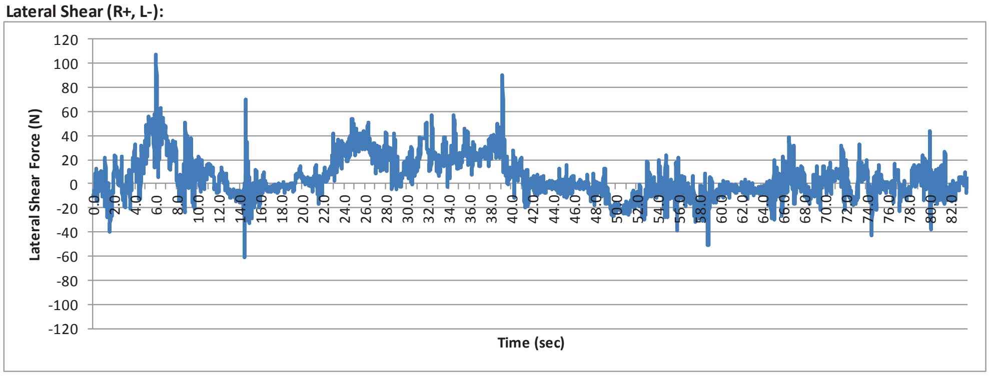
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



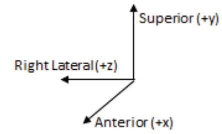
Lateral Shear (R+, L-):



Hard Turn FP Side - Day

Griffon MFTA - PDA: Postural Sequence

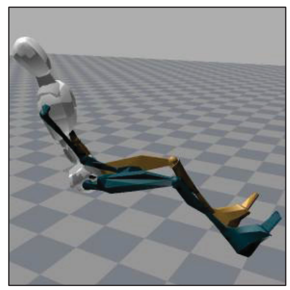
Postural Sequence:	Hard Turn FP Side (FP)
DAY	
Participant Number:	FP06
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
When banking to the FP side, the FP checks clearance to that side, then banks while keeping head level with horizon while viewing through corner of windscreen during turn; sometimes through the roof window.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

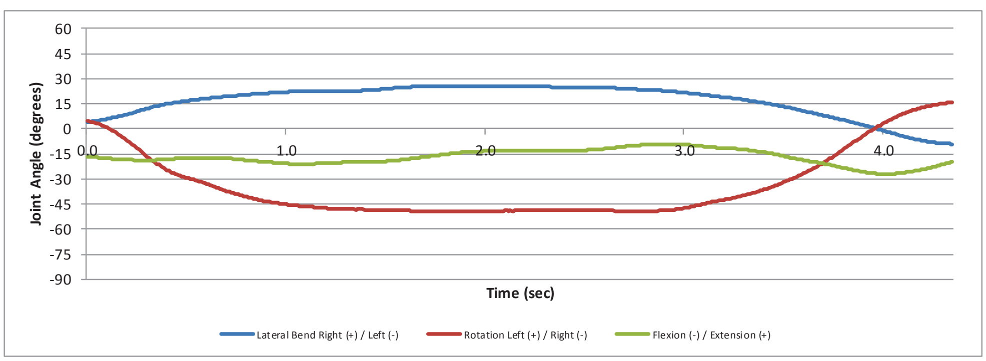
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	8.623	seconds

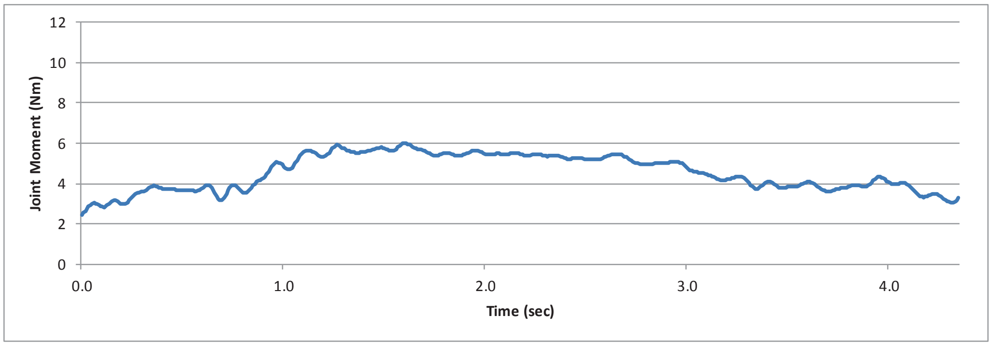
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	59.90	58.13	501.73
Tension (N)	NA	NA	NA
Anterior Shear (N)	16.42	6.90	49.75
Posterior Shear (N)	-14.96	-6.91	-12.31
Right Lateral Shear (N)	8.13	3.06	5.01
Left Lateral Shear (N)	-15.64	-8.19	-59.99
Torque (Resultant) (Nm)	4.25	3.93	24.24
Right Lateral Moment (+Mx) (Nm)	1.39	0.63	0.48
Left Lateral Moment (-Mx) (Nm)	-4.98	-3.04	-23.99
Left Axial Moment (+My) (Nm)	1.06	0.50	3.45
Right Axial Moment (-My) (Nm)	-0.86	-0.32	-0.57
Extension Moment (+Mz) (Nm)	4.24	2.30	13.62
Flexion Moment (-Mz) (Nm)	-3.64	-1.88	-8.51

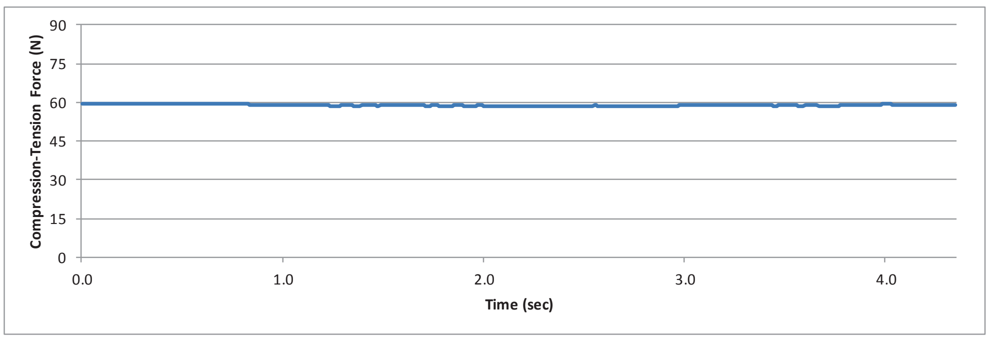
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	21.60	13.72
Left Lateral Bend	-6.67	-3.91
Left Axial Rotation	24.13	18.04
Right Axial Rotation	-56.44	-45.90
Extension	12.44	12.13
Flexion	-25.86	-13.92

Hard Turn FP Side – Day

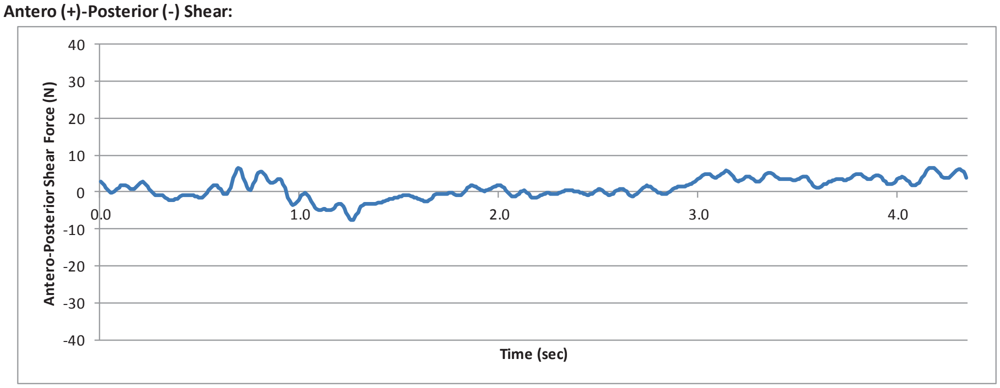
Resultant Neck Torque:



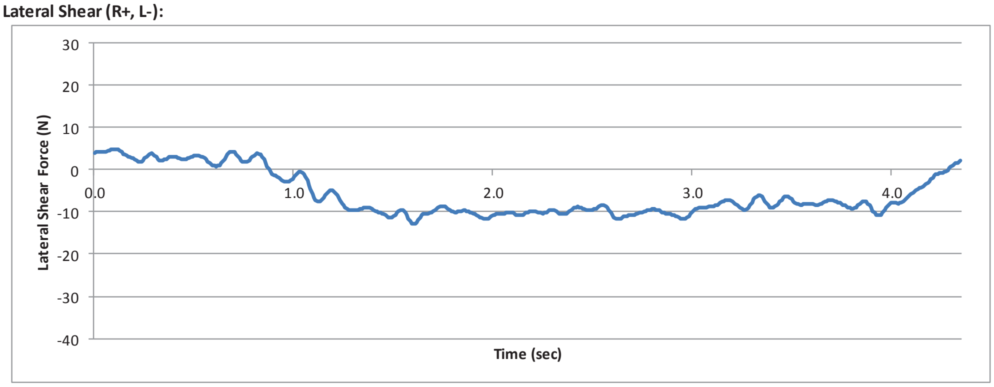
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



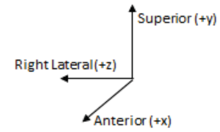
Lateral Shear (R+, L-):



Hard Turn FP Side - Night

Griffon MFTA - PDA: Postural Sequence

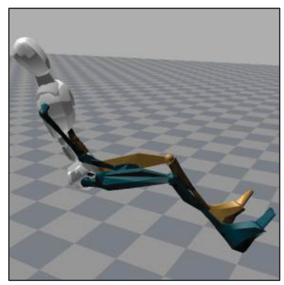
Postural Sequence:	Hard Turn FP Side (FP)
NIGHT	
Participant Number:	FP06
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
When banking to the FP side, the FP checks clearance to that side, then banks while keeping head level with horizon while viewing through corner of windscreen during turn; sometimes through the roof window.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

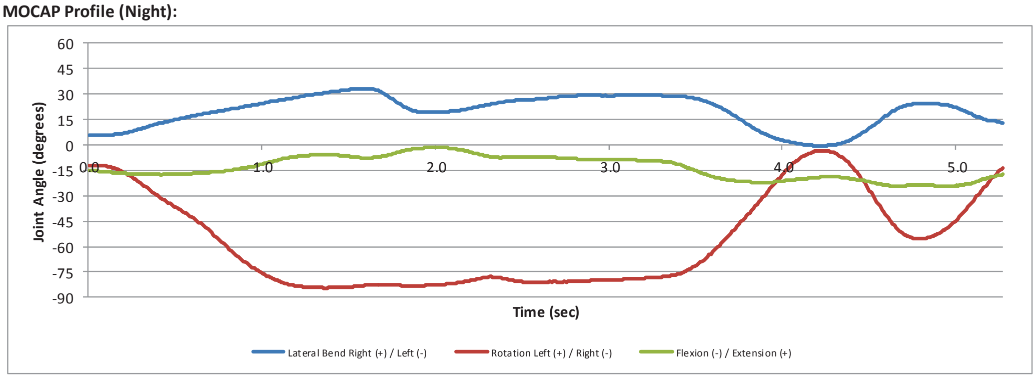
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



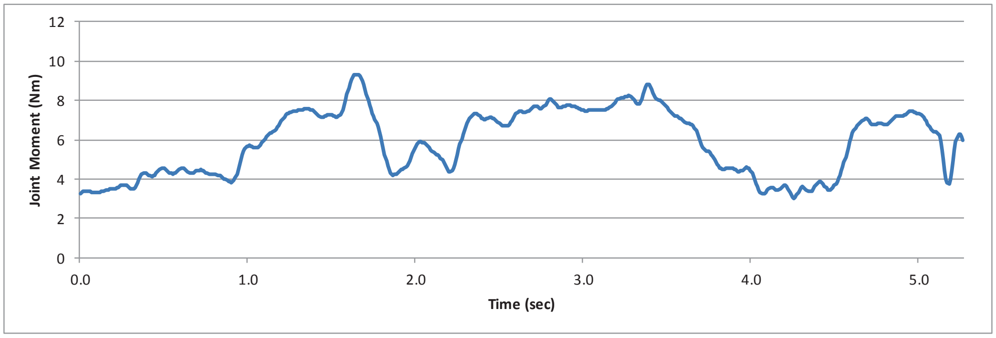
Posture Duration:	10.197	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

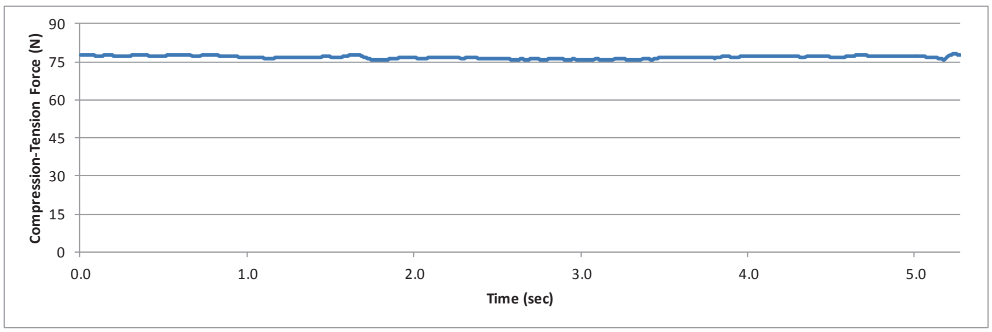
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	76.15	73.29	747.97	Right Lateral Bend	22.14	11.82
Tension (N)	NA	NA	NA	Left Lateral Bend	-5.03	-2.89
Anterior Shear (N)	17.15	6.60	40.74	Left Axial Rotation	38.16	23.28
Posterior Shear (N)	-14.20	-9.82	-39.59	Right Axial Rotation	-66.40	-48.81
Right Lateral Shear (N)	12.11	10.91	45.43	Extension	18.41	13.13
Left Lateral Shear (N)	-18.30	-8.25	-49.83	Flexion	-24.34	-15.12
Torque (Resultant) (Nm)	5.57	4.59	33.48			
Right Lateral Moment (+Mx) (Nm	2.10	0.75	2.60			
Left Lateral Moment (-Mx) (Nm)	-6.05	-3.18	-25.87			
Left Axial Moment (+My) (Nm)	1.65	0.44	2.80			
Right Axial Moment (-My) (Nm)	-0.90	-0.33	-1.25			
Extension Moment (+Mz) (Nm)	5.98	3.18	25.18			
Flexion Moment (-Mz) (Nm)	-2.43	-2.65	-7.60			

Hard Turn FP Side - Night

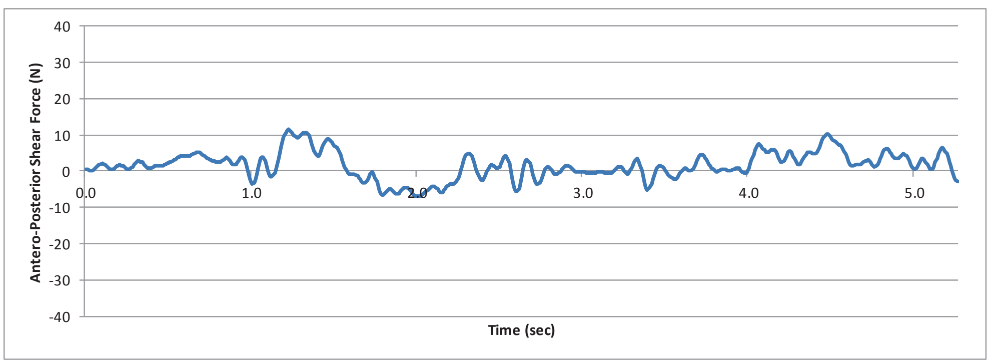
Resultant Neck Torque:



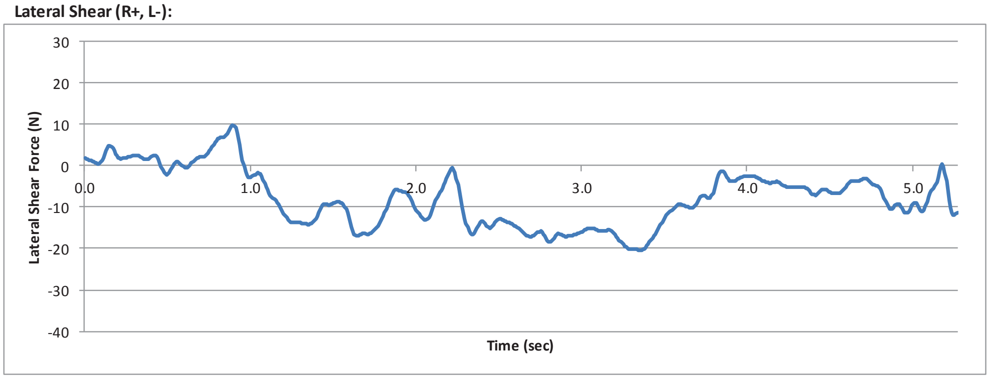
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



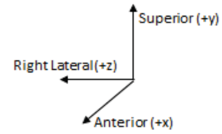
Lateral Shear (R+, L-):



Hard Turn NFP Side - Day

Griffon MFTA - PDA: Postural Sequence

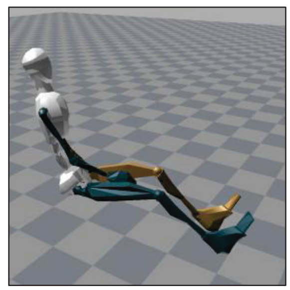
Postural Sequence:	Hard Turn NFP Side (FP)
DAY	
Participant # (Sample Graphs):	FP03
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
Banking to the opposite side, the NFP confirms area clear and the FP observes turn through the far corner of the windscreen.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

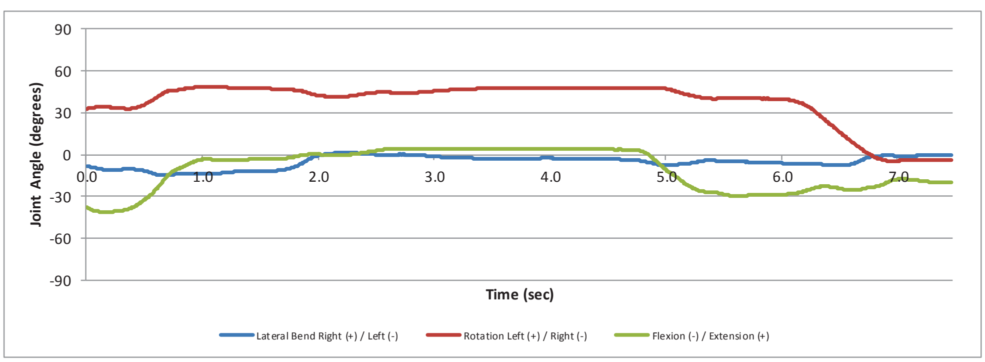
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



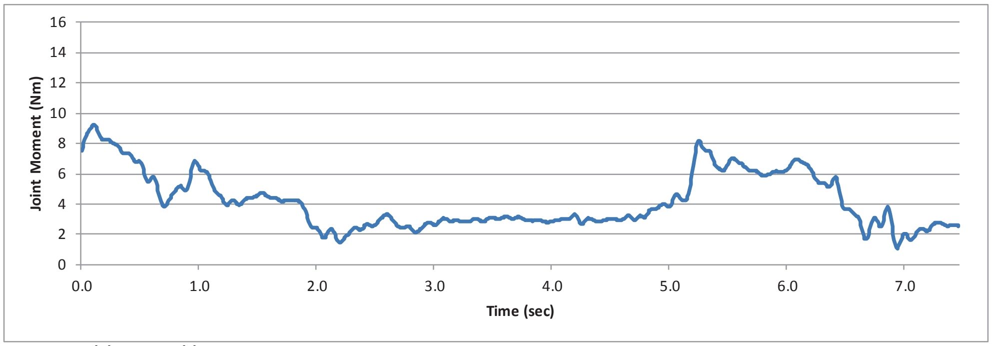
Posture Duration:	7.975	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

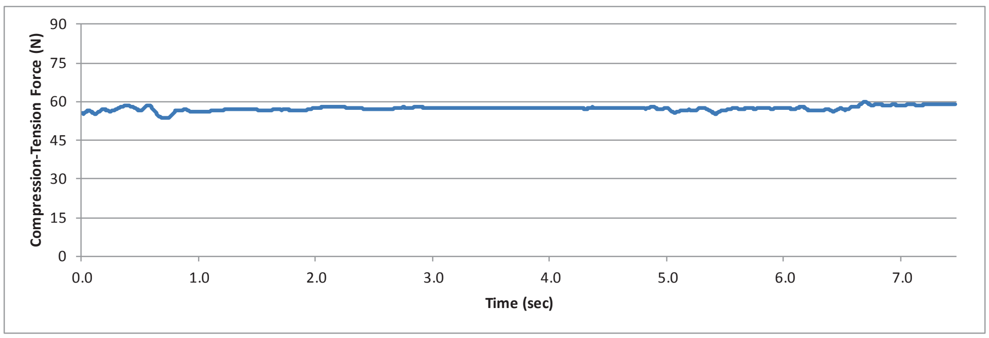
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	59.67	57.74	460.98	Right Lateral Bend	6.57	4.43
Tension (N)	NA	NA	NA	Left Lateral Bend	-11.39	-6.44
Anterior Shear (N)	13.26	6.05	18.61	Left Axial Rotation	39.71	36.94
Posterior Shear (N)	-24.21	-8.76	-43.00	Right Axial Rotation	-8.50	-4.75
Right Lateral Shear (N)	17.18	8.73	55.06	Extension	2.43	3.21
Left Lateral Shear (N)	-15.83	-10.71	-23.92	Flexion	-30.37	-15.51
Torque (Resultant) (Nm)	4.26	3.92	17.87			
Right Lateral Moment (+Mx) (Nm)	3.42	2.31	13.20			
Left Lateral Moment (-Mx) (Nm)	-1.74	-1.37	-3.10			
Left Axial Moment (+My) (Nm)	0.89	0.54	1.34			
Right Axial Moment (-My) (Nm)	-0.68	-0.17	-0.93			
Extension Moment (+Mz) (Nm)	6.56	2.97	21.24			
Flexion Moment (-Mz) (Nm)	-2.13	-1.03	-3.39			

Hard Turn NFP Side – Day

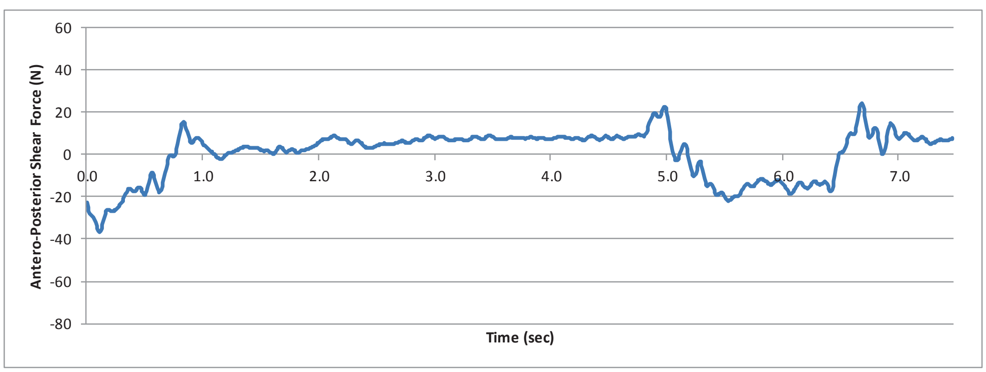
Resultant Neck Torque:



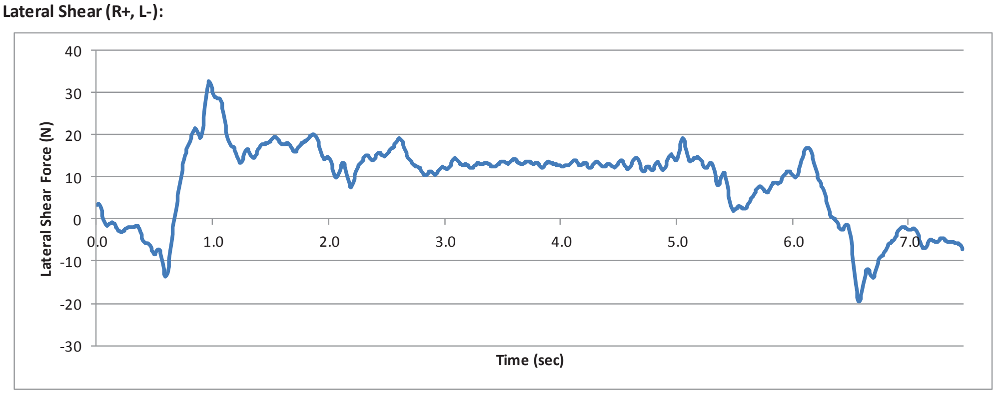
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



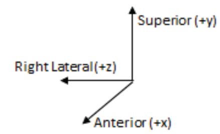
Lateral Shear (R+, L-):



Hard Turn NFP Side - Night

Griffon MFTA - PDA: Postural Sequence

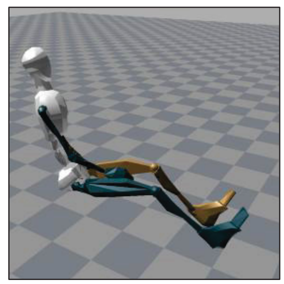
Postural Sequence:	Hard Turn NFP Side (FP)
NIGHT	
Participant # (Sample Graphs):	FP03
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Banking to the opposite side, the NFP confirms area clear and the FP observes turn through the far corner of the windscreen.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

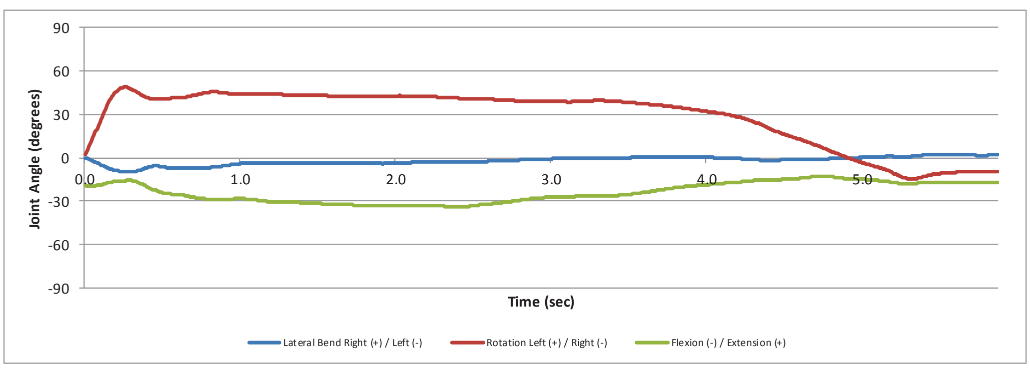
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



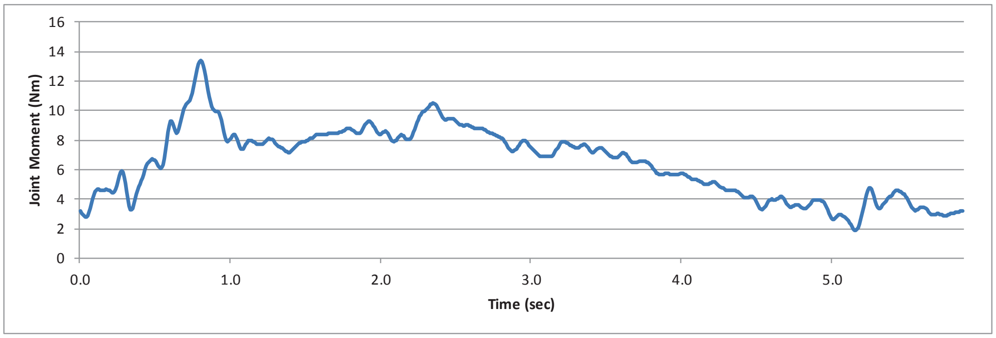
Posture Duration:	10.960	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

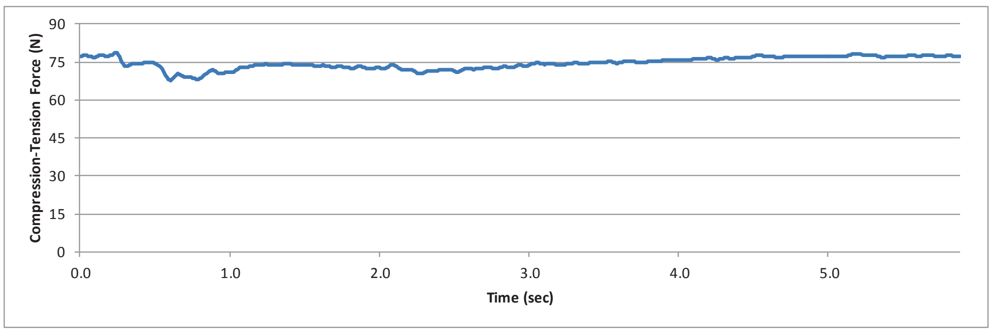
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	77.79	75.60	829.24	Right Lateral Bend	12.89	10.01
Tension (N)	NA	NA	NA	Left Lateral Bend	-13.14	-9.88
Anterior Shear (N)	17.94	3.88	15.97	Left Axial Rotation	58.34	46.97
Posterior Shear (N)	-30.48	-10.98	-75.22	Right Axial Rotation	-39.08	-25.18
Right Lateral Shear (N)	21.03	9.60	76.16	Extension	9.52	5.40
Left Lateral Shear (N)	-16.56	-5.11	-25.86	Flexion	-23.72	-13.32
Torque (Resultant) (Nm)	5.40	4.15	32.49			
Right Lateral Moment (+Mx) (Nm	4.03	2.64	23.32			
Left Lateral Moment (-Mx) (Nm)	-3.33	-0.85	-3.01			
Left Axial Moment (+My) (Nm)	1.33	0.30	1.30			
Right Axial Moment (-My) (Nm)	-1.59	-0.40	-2.67			
Extension Moment (+Mz) (Nm)	6.44	2.87	29.65			
Flexion Moment (-Mz) (Nm)	-1.81	-0.88	-0.93			

Hard Turn NFP Side - Night

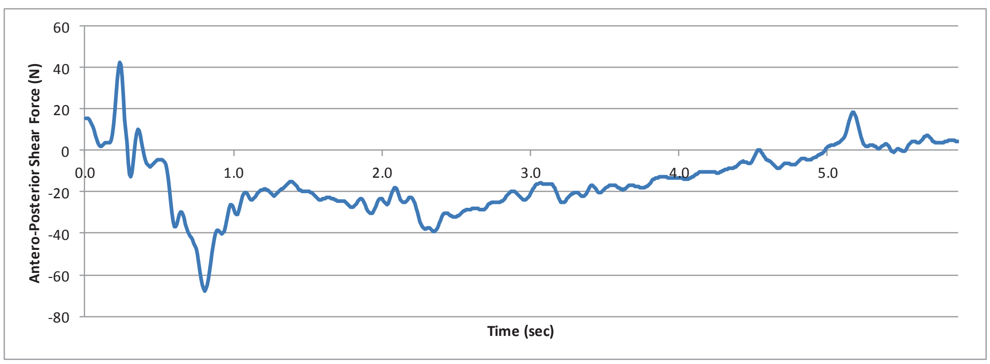
Resultant Neck Torque:



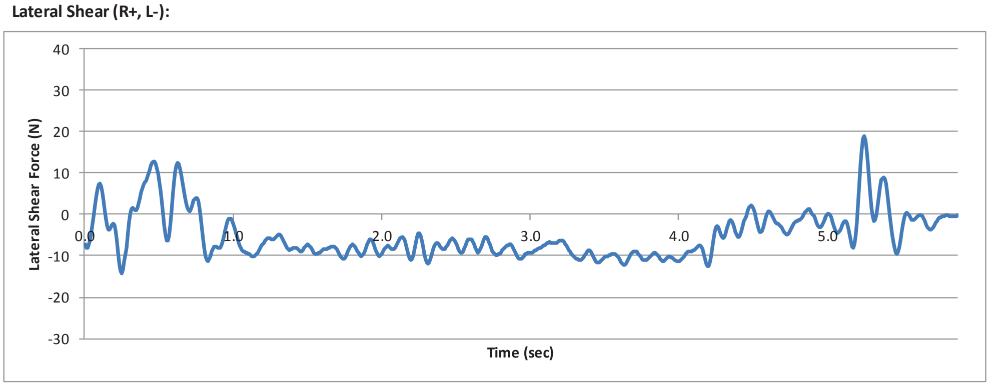
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



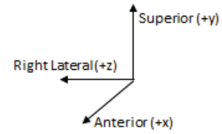
Lateral Shear (R+, L-):



Inside Scan Ceiling Switches - Day

Griffon MFTA - PDA: Postural Sequence

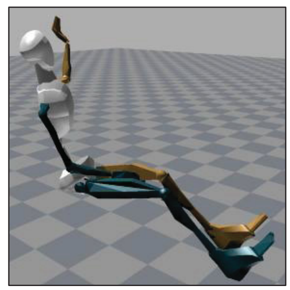
Postural Sequence:	Inside Scan Ceiling Switches (FP)
DAY	
Participant # (Sample Graphs):	FP02
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
Pilot views settings on ceiling switches and dials, in addition to sense of touch for setting positions.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

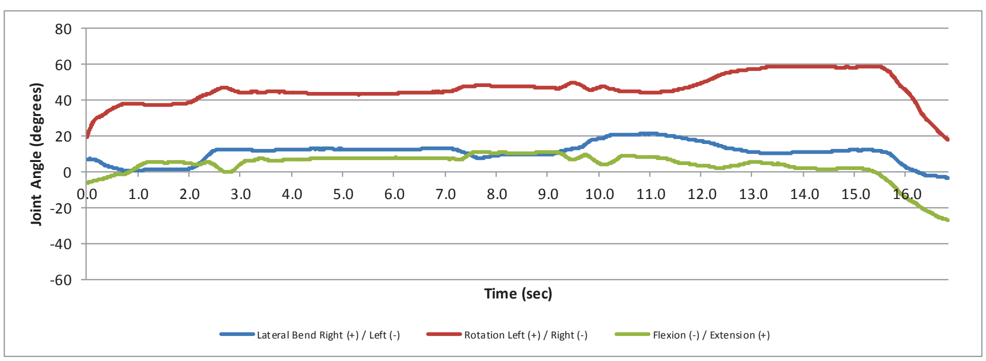
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



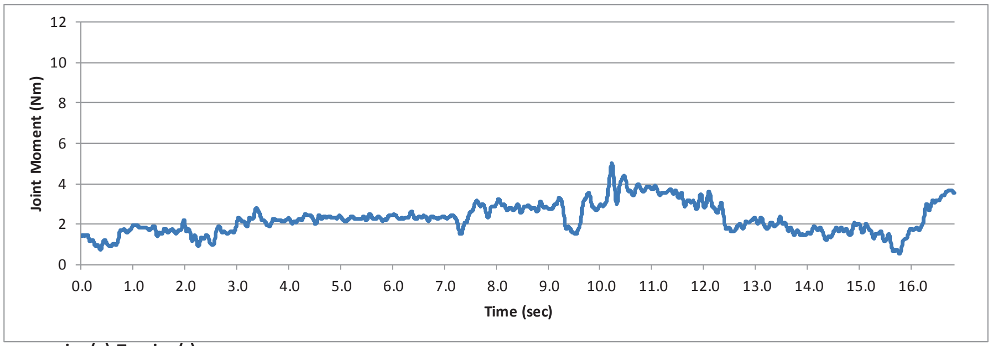
Posture Duration:	11.227	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

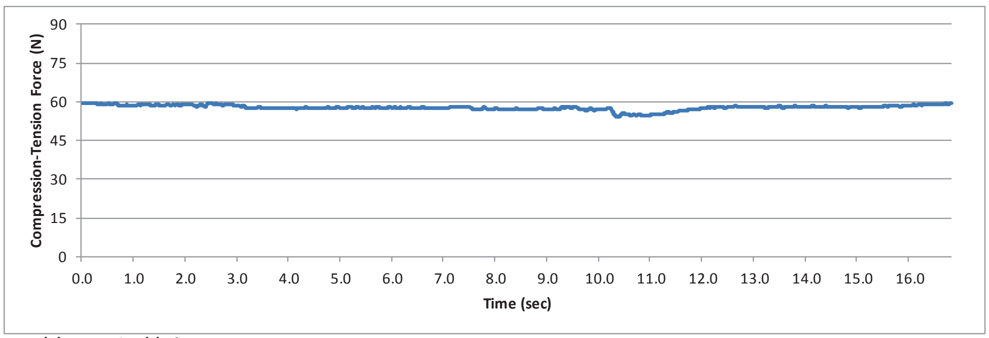
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	60.54	58.04	652.06	Right Lateral Bend	7.04	8.54
Tension (N)	NA	NA	NA	Left Lateral Bend	-13.13	-5.35
Anterior Shear (N)	16.95	8.08	55.27	Left Axial Rotation	50.45	41.45
Posterior Shear (N)	-16.80	-8.62	-37.86	Right Axial Rotation	-1.54	-1.14
Right Lateral Shear (N)	22.76	8.75	67.20	Extension	11.20	6.15
Left Lateral Shear (N)	-15.72	-5.67	-26.87	Flexion	-25.97	-10.36
Torque (Resultant) (Nm)	3.88	2.79	17.92			
Right Lateral Moment (+Mx) (Nm)	3.92	1.59	10.96			
Left Lateral Moment (-Mx) (Nm)	-2.83	-0.68	-3.92			
Left Axial Moment (+My) (Nm)	1.02	0.29	2.54			
Right Axial Moment (-My) (Nm)	-0.75	-0.15	-0.38			
Extension Moment (+Mz) (Nm)	4.83	2.22	11.90			
Flexion Moment (-Mz) (Nm)	-2.18	-1.53	-8.97			

Inside Scan Ceiling Switches – Day

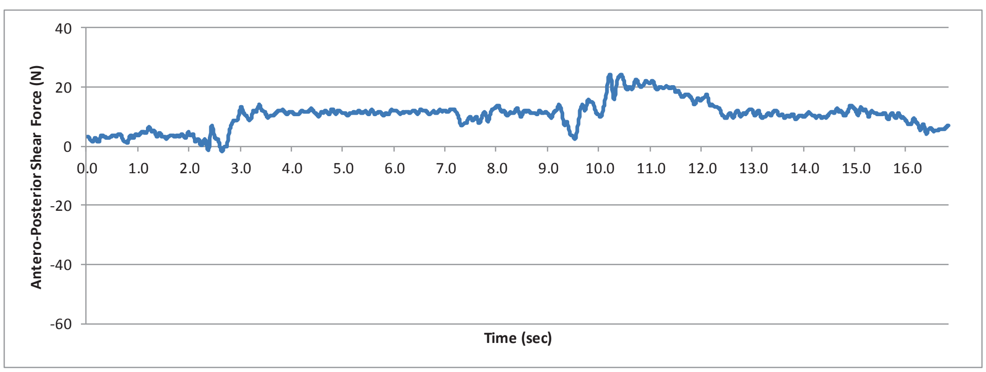
Resultant Neck Torque:



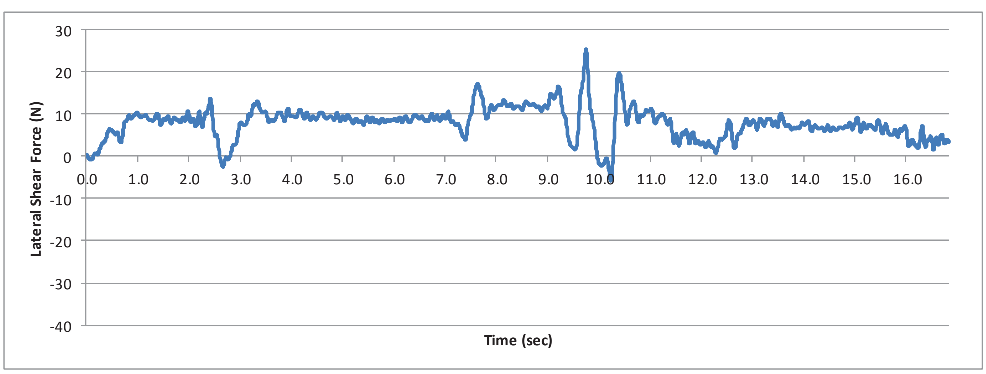
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



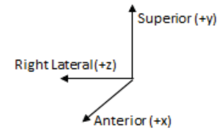
Lateral Shear (R+, L-):



Inside Scan Ceiling Switches - Night

Griffon MFTA - PDA: Postural Sequence

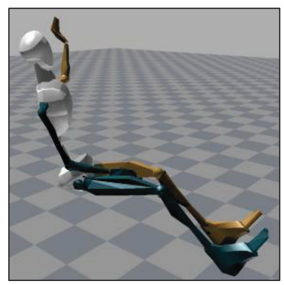
Postural Sequence:	Inside Scan Ceiling Switches (FP)
NIGHT	
Participant # (Sample Graphs):	FP02
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Pilot views settings on ceiling switches and dials, in addition to sense of touch for setting positions.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

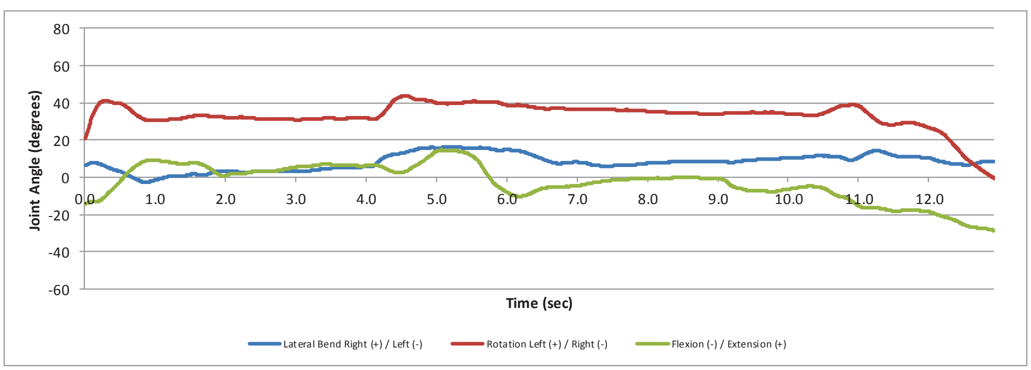
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



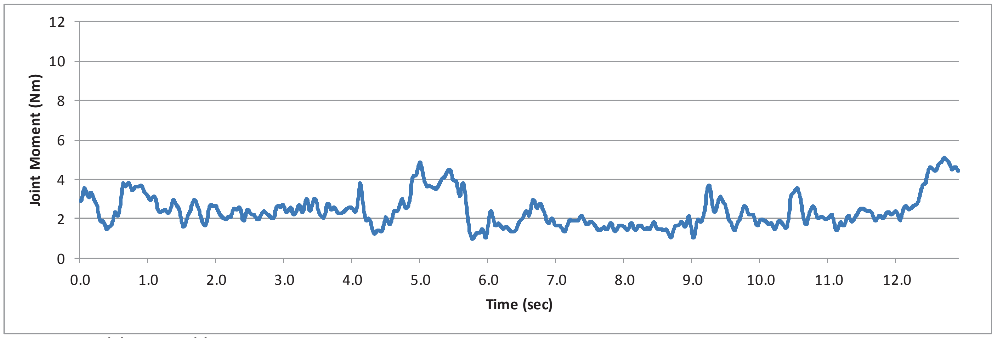
Posture Duration:	11.910	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

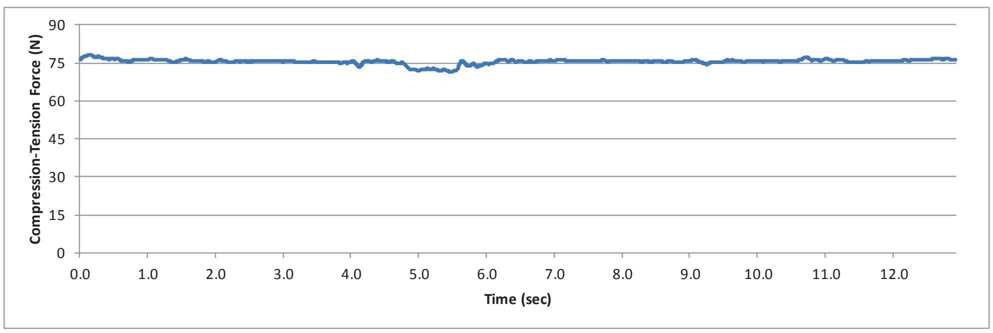
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	73.68	70.50	840.27	Right Lateral Bend	8.92	6.18
Tension (N)	NA	NA	NA	Left Lateral Bend	-9.64	-7.99
Anterior Shear (N)	13.21	4.57	29.55	Left Axial Rotation	56.01	43.05
Posterior Shear (N)	-29.97	-12.19	-88.68	Right Axial Rotation	-0.40	-0.22
Right Lateral Shear (N)	20.81	10.47	86.29	Extension	7.67	4.88
Left Lateral Shear (N)	-11.74	-9.37	-34.46	Flexion	-31.25	-14.68
Torque (Resultant) (Nm)	3.86	3.75	25.57			
Right Lateral Moment (+Mx) (Nm	3.81	1.37	13.62			
Left Lateral Moment (-Mx) (Nm)	-1.85	-0.53	-1.03			
Left Axial Moment (+My) (Nm)	1.52	0.64	3.46			
Right Axial Moment (-My) (Nm)	-0.84	-0.21	-1.38			
Extension Moment (+Mz) (Nm)	6.43	3.58	34.21			
Flexion Moment (-Mz) (Nm)	-2.27	-0.97	-4.60			

Inside Scan Ceiling Switches - Night

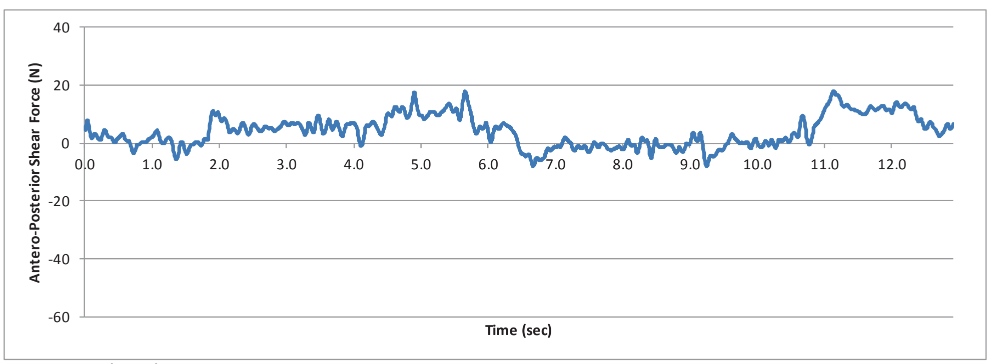
Resultant Neck Torque:



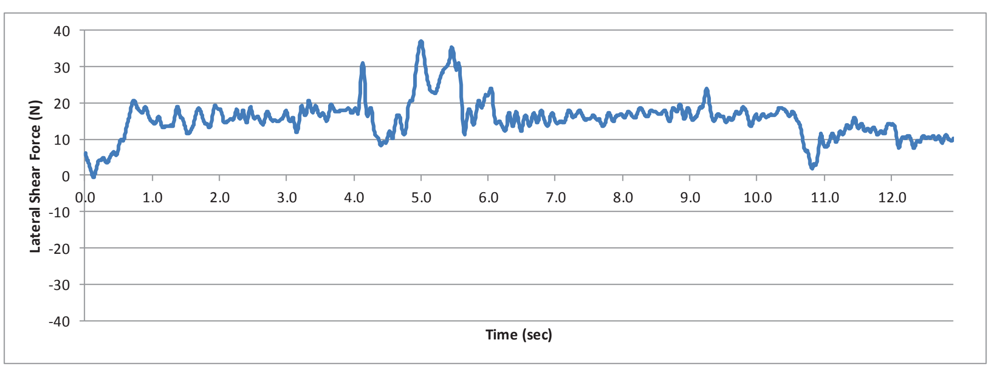
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



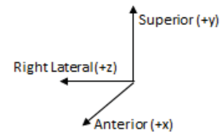
Lateral Shear (R+, L-):



Inside Scan Dash Gauges – Day

Griffon MFTA - PDA: Postural Sequence

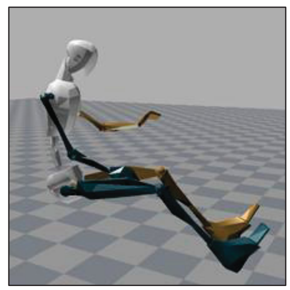
Postural Sequence:	Inside Scan Dash Gauges (FP)
DAY	
Participant # (Sample Graphs):	FP07
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
FP scans dash gauges, warning lights, and switches from the center of the dash to their side of the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

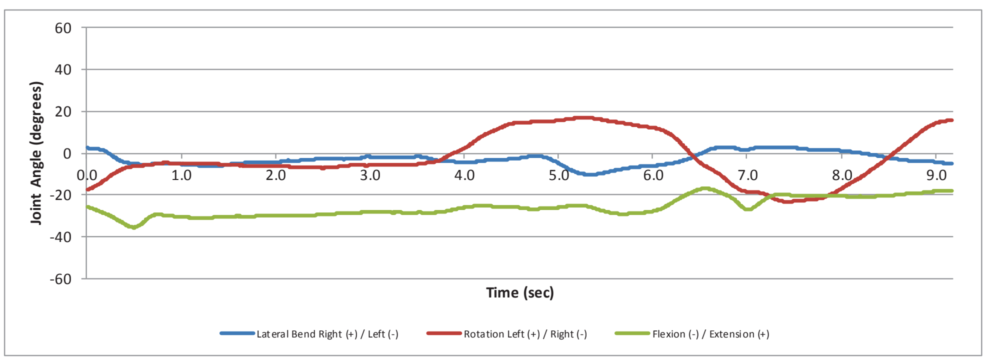
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



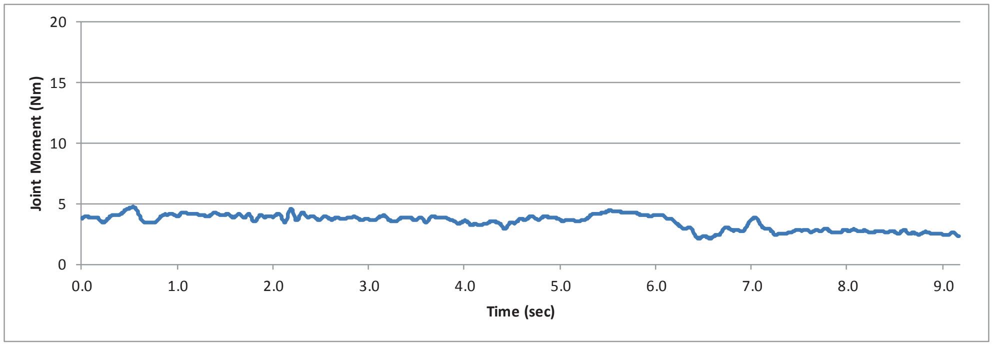
Posture Duration:	11.589	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

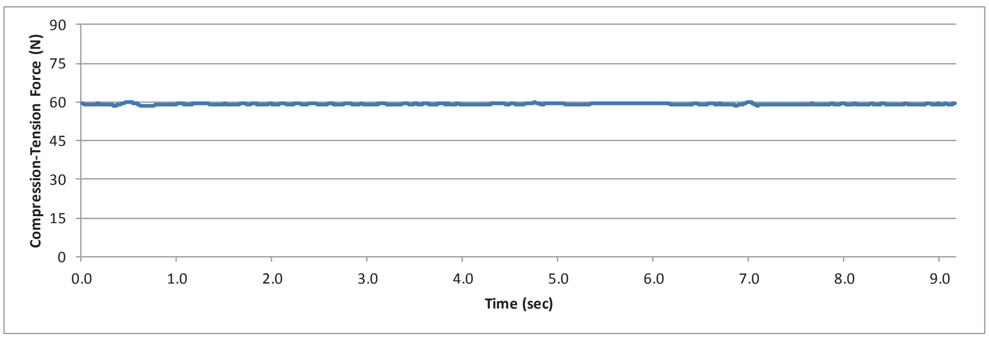
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	59.70	58.72	681.00	Right Lateral Bend	5.83	4.63
Tension (N)	NA	NA	NA	Left Lateral Bend	-14.41	-8.56
Anterior Shear (N)	9.81	6.87	57.71	Left Axial Rotation	24.19	17.34
Posterior Shear (N)	-7.46	-2.16	-20.65	Right Axial Rotation	-17.09	-12.79
Right Lateral Shear (N)	13.15	6.17	54.80	Extension	NA	NA
Left Lateral Shear (N)	-4.84	-2.26	-6.15	Flexion	-38.64	-28.51
Torque (Resultant) (Nm)	2.32	4.40	21.88			
Right Lateral Moment (+Mx) (Nm)	3.57	1.83	17.05			
Left Lateral Moment (-Mx) (Nm)	-1.21	-0.70	-1.60			
Left Axial Moment (+My) (Nm)	0.55	0.15	0.48			
Right Axial Moment (-My) (Nm)	-0.87	-0.44	-3.73			
Extension Moment (+Mz) (Nm)	5.29	3.75	43.53			
Flexion Moment (-Mz) (Nm)	NA	NA	NA			

Inside Scan Dash Gauges – Day

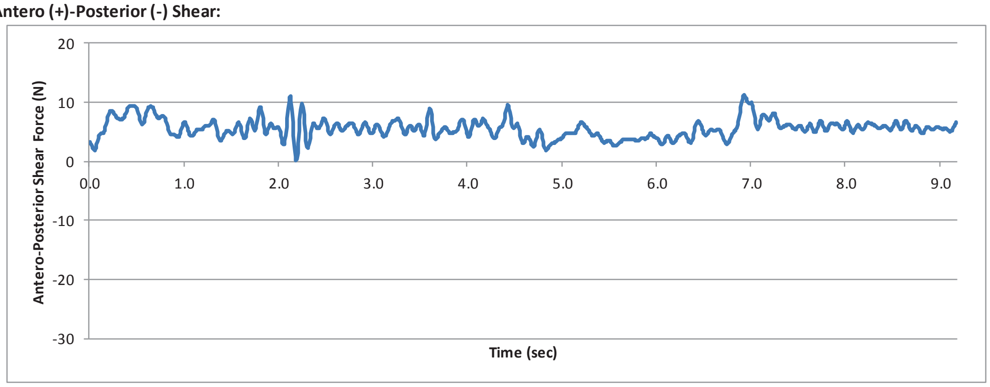
Resultant Neck Torque:



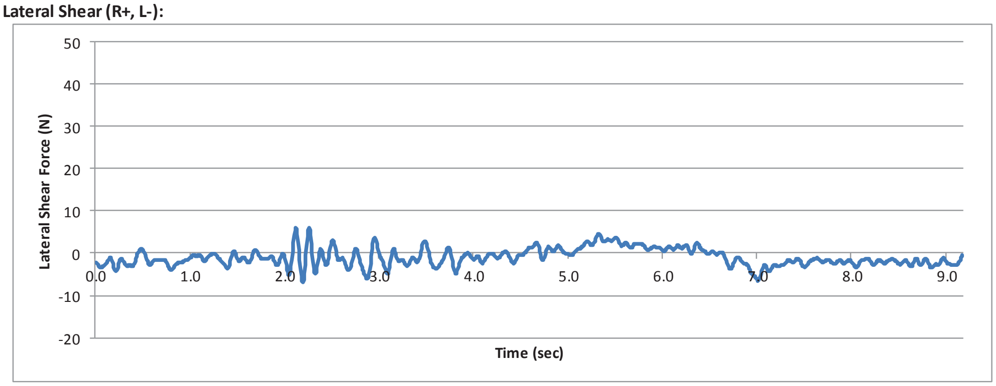
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



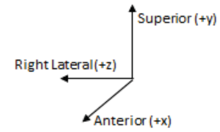
Lateral Shear (R+, L-):



Inside Scan Dash Gauges – Night

Griffon MFTA - PDA: Postural Sequence

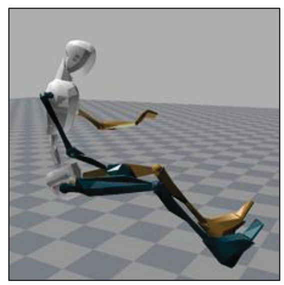
Postural Sequence:	Inside Scan Dash Gauges (FP)
NIGHT	
Participant # (Sample Graphs):	FP07
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
FP scans dash gauges, warning lights, and switches from the center of the dash to their side of the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

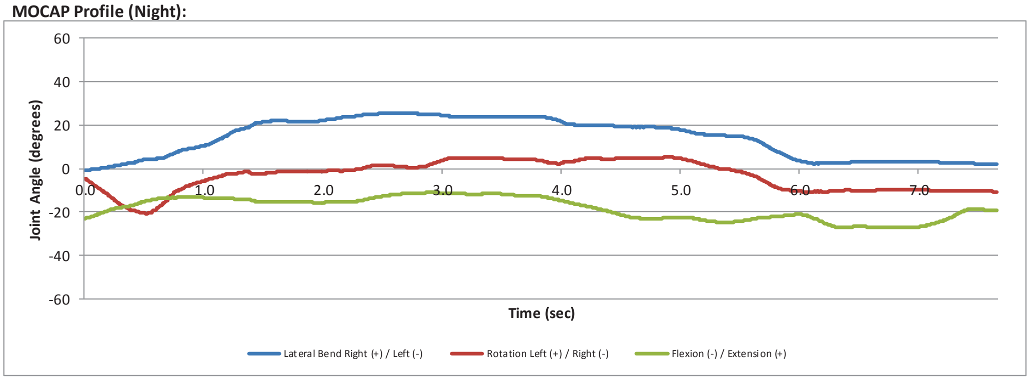
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



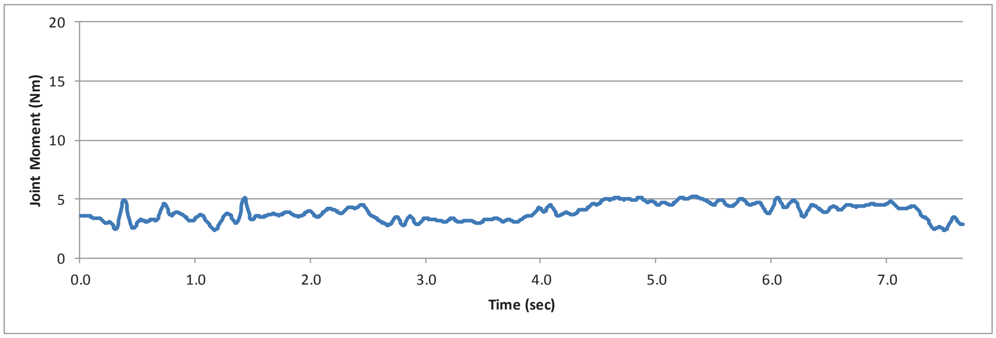
Posture Duration:	10.590	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

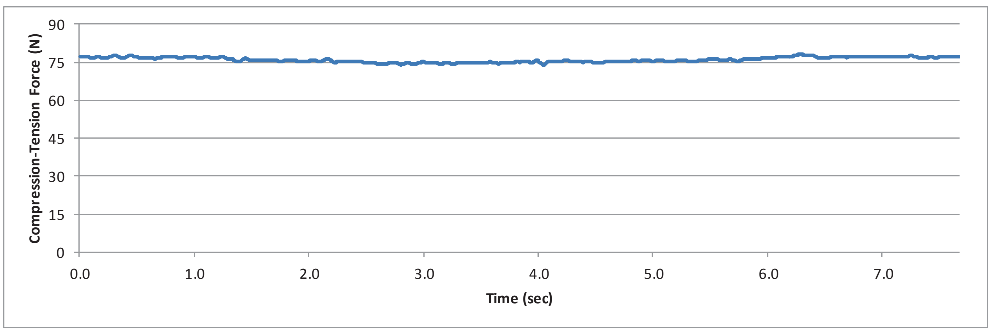
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	76.20	74.00	784.28	Right Lateral Bend	11.67	7.86
Tension (N)	NA	NA	NA	Left Lateral Bend	-10.69	-7.66
Anterior Shear (N)	9.29	4.92	14.15	Left Axial Rotation	22.00	16.17
Posterior Shear (N)	-13.94	-5.16	-39.83	Right Axial Rotation	-17.06	-8.18
Right Lateral Shear (N)	20.05	9.51	85.46	Extension	1.52	0.95
Left Lateral Shear (N)	-7.19	-4.38	-11.73	Flexion	-33.17	-19.18
Torque (Resultant) (Nm)	6.14	4.78	36.21			
Right Lateral Moment (+Mx) (Nm	3.97	2.22	13.94			
Left Lateral Moment (-Mx) (Nm)	-2.04	-0.86	-3.70			
Left Axial Moment (+My) (Nm)	0.75	0.32	0.62			
Right Axial Moment (-My) (Nm)	-1.32	-0.43	-3.74			
Extension Moment (+Mz) (Nm)	6.83	4.19	44.32			
Flexion Moment (-Mz) (Nm)	-0.31	-0.20	-0.02			

Inside Scan Dash Gauges – Night

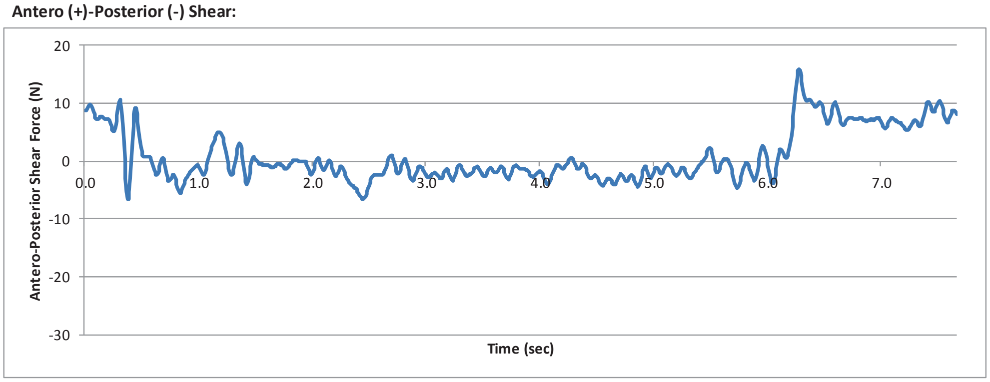
Resultant Neck Torque:



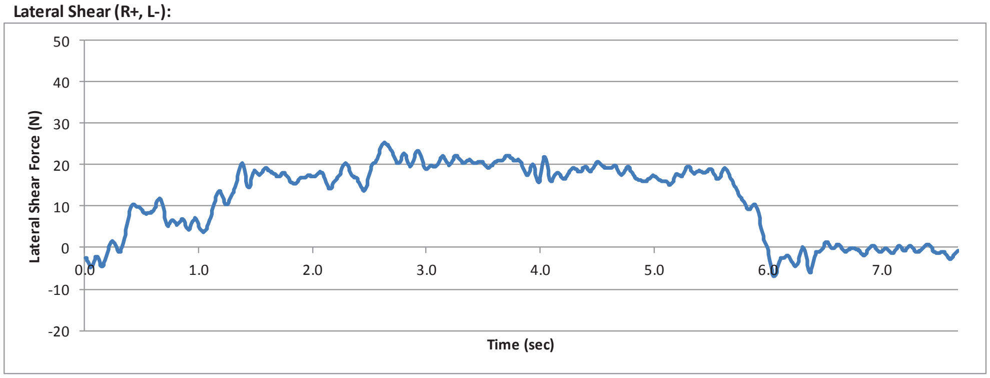
Compression(+)-Tension(-):



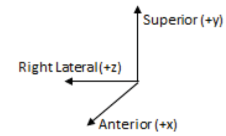
Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):



Outside Scan Chin Bubble - Day



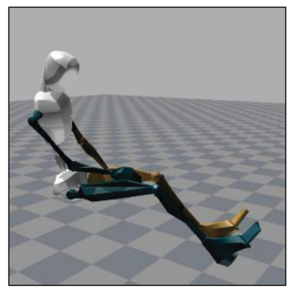
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Outside Scan Chin Bubble (FP)
DAY	
Participant # (Sample Graphs):	FP04
Role:	Flying Pilot
Helmet Condition:	Helmet Only

Task Description:	Equipment Considerations:
Occasionally, FP must look down through floor area at feet when landing in difficult visibility (e.g. snow ball).	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

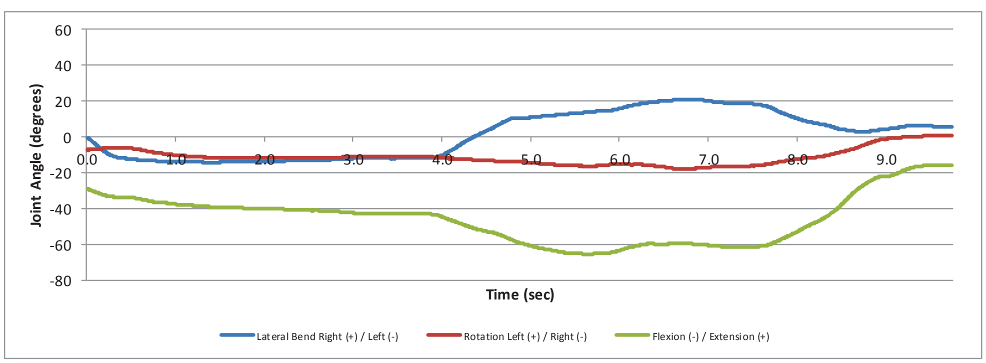
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	10.258	seconds

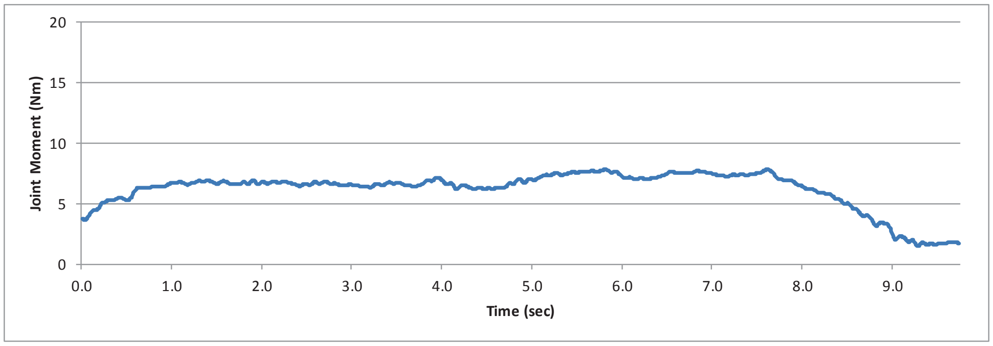
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	59.57	58.36	599.16
Tension (N)	NA	NA	NA
Anterior Shear (N)	9.23	3.30	34.61
Posterior Shear (N)	-5.62	-4.71	-8.83
Right Lateral Shear (N)	10.12	7.51	31.47
Left Lateral Shear (N)	-13.10	-10.22	-70.67
Torque (Resultant) (Nm)	5.53	6.01	44.09
Right Lateral Moment (+Mx) (Nm)	2.48	1.81	6.79
Left Lateral Moment (-Mx) (Nm)	-3.60	-1.74	-12.68
Left Axial Moment (+My) (Nm)	1.57	1.19	7.87
Right Axial Moment (-My) (Nm)	-1.14	-0.61	-2.81
Extension Moment (+Mz) (Nm)	6.72	5.44	55.84
Flexion Moment (-Mz) (Nm)	NA	NA	NA

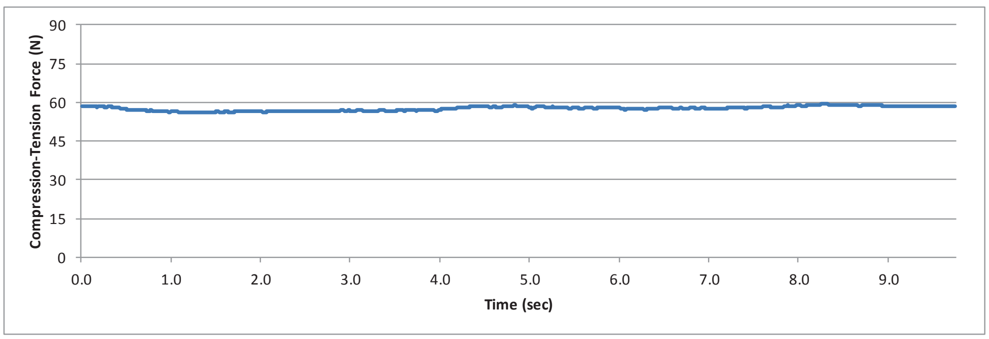
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	18.89	9.45
Left Lateral Bend	-12.41	-8.07
Left Axial Rotation	16.96	14.91
Right Axial Rotation	-24.91	-15.02
Extension	NA	NA
Flexion	-52.65	-43.70

Outside Scan Chin Bubble - Day

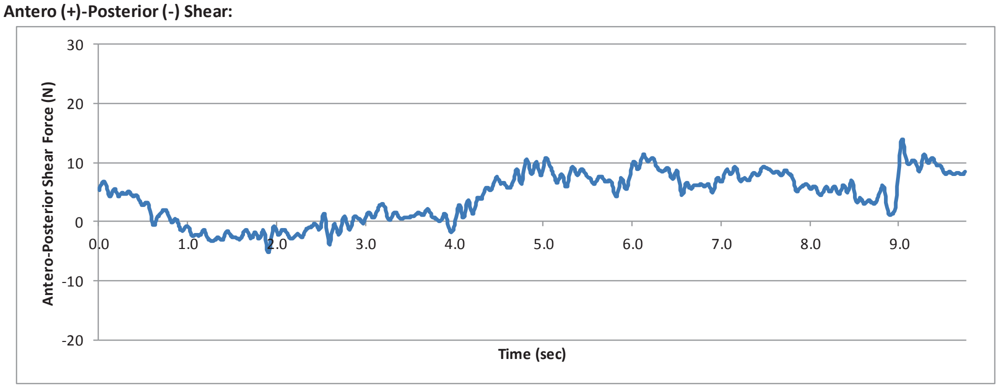
Resultant Neck Torque:



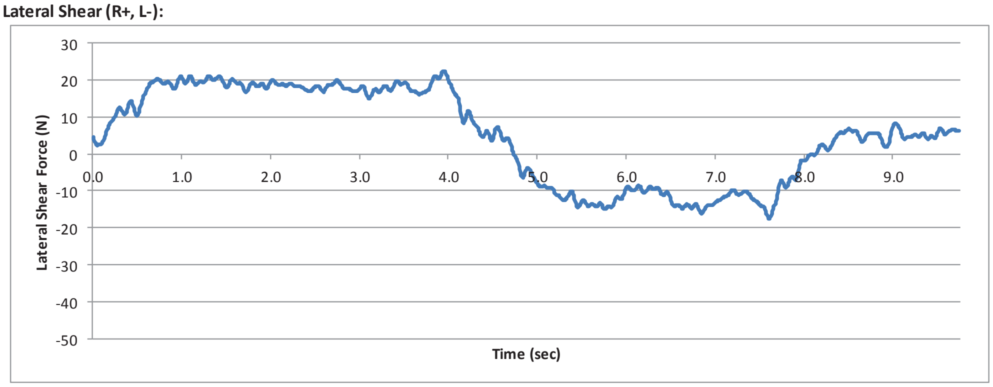
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



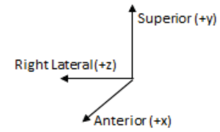
Lateral Shear (R+, L-):



Outside Scan Chin Bubble - Night

Griffon MFTA - PDA: Postural Sequence

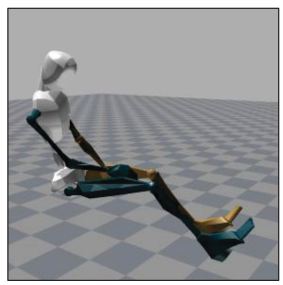
Postural Sequence:	Outside Scan Chin Bubble (FP)
NIGHT	
Participant # (Sample Graphs):	FP04
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
Occasionally, FP must look down through floor area at feet when landing in difficult visibility (e.g. snow ball).	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

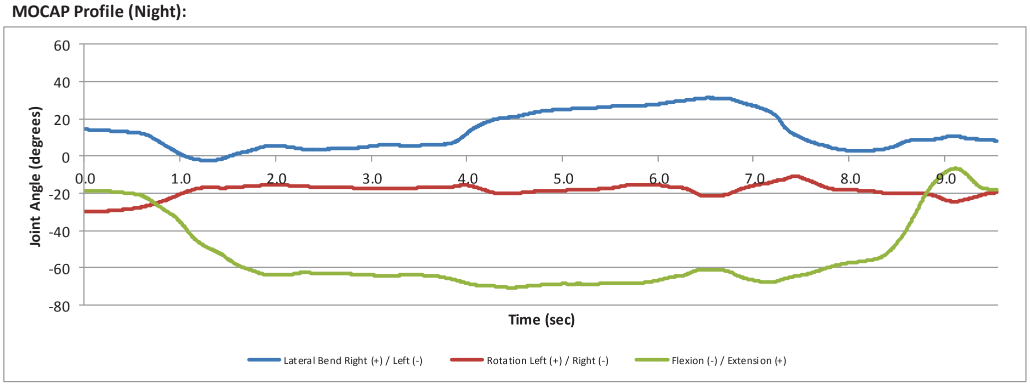
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	11.033	seconds

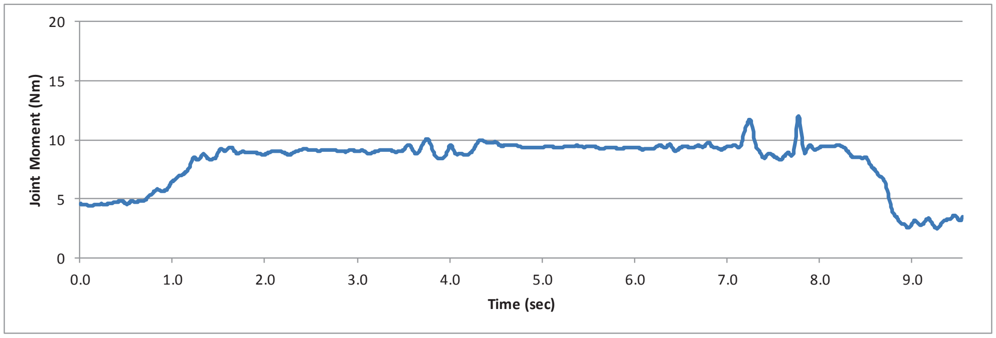
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	76.20	74.24	819.79
Tension (N)	NA	NA	NA
Anterior Shear (N)	15.51	8.77	76.76
Posterior Shear (N)	-6.80	-2.88	-8.27
Right Lateral Shear (N)	12.52	8.12	29.50
Left Lateral Shear (N)	-23.30	-12.15	-89.99
Torque (Resultant) (Nm)	7.53	7.67	60.48
Right Lateral Moment (+Mx) (Nm	1.20	0.53	0.46
Left Lateral Moment (-Mx) (Nm)	-5.53	-2.58	-26.21
Left Axial Moment (+My) (Nm)	3.32	1.47	12.17
Right Axial Moment (-My) (Nm)	-1.26	-1.03	-2.85
Extension Moment (+Mz) (Nm)	9.48	6.88	76.02
Flexion Moment (-Mz) (Nm)	NA	NA	NA

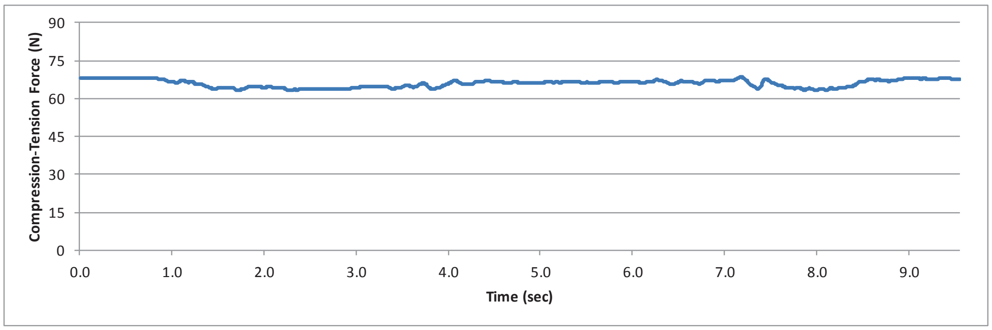
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	24.87	12.30
Left Lateral Bend	-5.12	-3.43
Left Axial Rotation	13.06	4.64
Right Axial Rotation	-32.22	-18.64
Extension	NA	NA
Flexion	-64.45	-47.86

Outside Scan Chin Bubble - Night

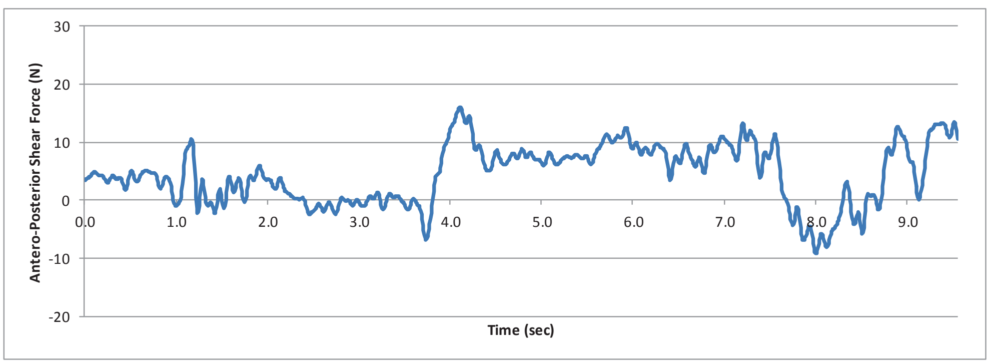
Resultant Neck Torque:



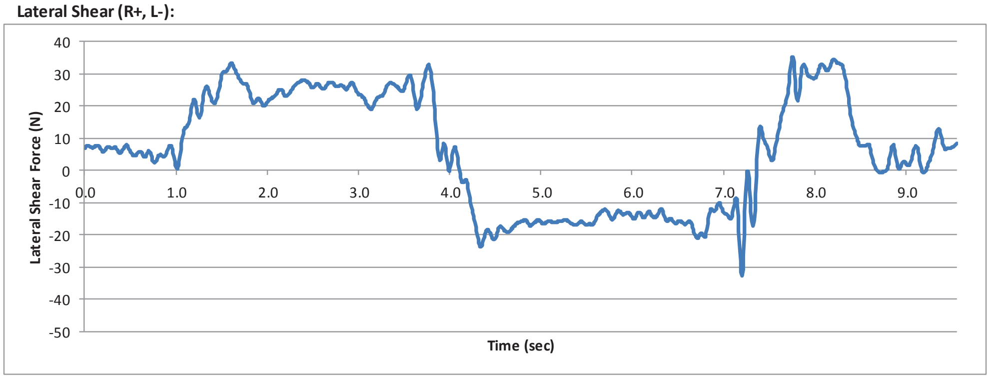
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



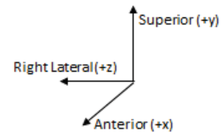
Lateral Shear (R+, L-):



Outside Scan Confined – Day

Griffon MFTA - PDA: Postural Sequence

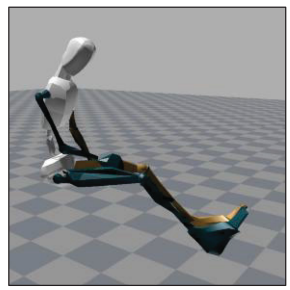
Postural Sequence:	Outside Scan Confined (FP)
DAY	
Participant # (Sample Graphs):	FP03
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
More scanning looks than Outside Scan Regular, with more views to the side and steeply down for landing position. More frequent scanning at night.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

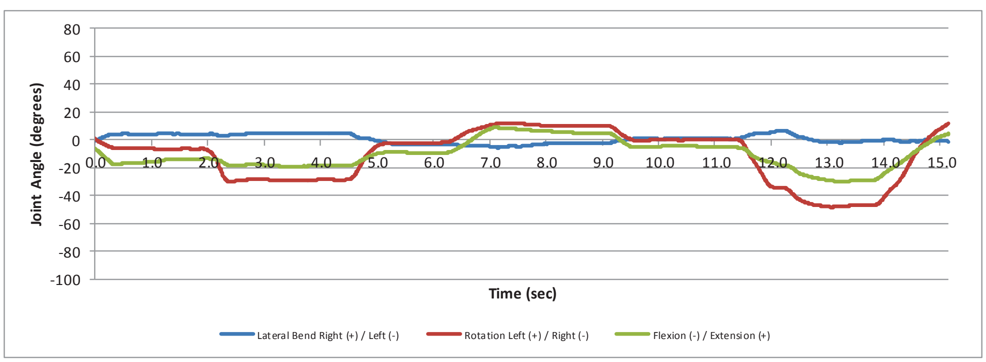
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	16.172	seconds

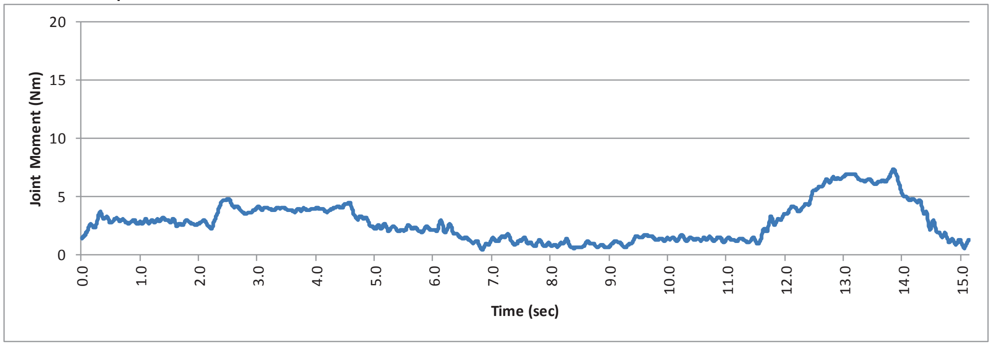
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	59.85	58.77	950.93
Tension (N)	NA	NA	NA
Anterior Shear (N)	9.38	5.80	66.80
Posterior Shear (N)	-26.17	-6.71	-46.94
Right Lateral Shear (N)	6.01	3.37	10.89
Left Lateral Shear (N)	-11.37	-4.91	-63.51
Torque (Resultant) (Nm)	2.97	4.14	28.69
Right Lateral Moment (+Mx) (Nm)	1.97	1.20	4.34
Left Lateral Moment (-Mx) (Nm)	-3.65	-1.98	-24.89
Left Axial Moment (+My) (Nm)	0.96	0.47	5.66
Right Axial Moment (-My) (Nm)	-0.58	-0.16	-0.65
Extension Moment (+Mz) (Nm)	5.95	3.66	55.21
Flexion Moment (-Mz) (Nm)	-1.25	-0.57	-0.93

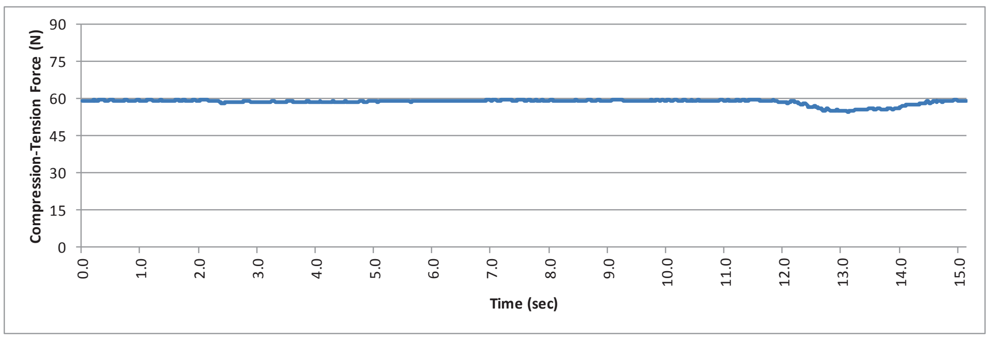
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	15.41	10.84
Left Lateral Bend	-8.52	-6.61
Left Axial Rotation	39.51	24.88
Right Axial Rotation	-53.44	-26.67
Extension	4.54	5.42
Flexion	-37.58	-27.06

Outside Scan Confined – Day

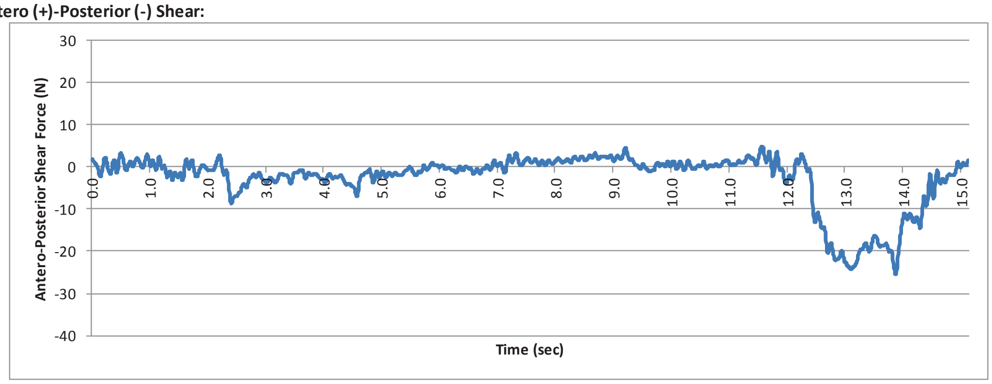
Resultant Neck Torque:



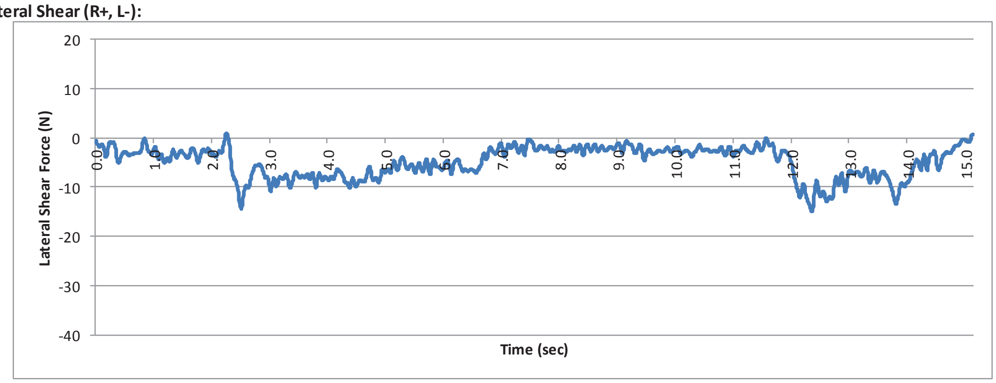
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



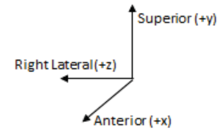
Lateral Shear (R+, L-):



Outside Scan Confined – Night

Griffon MFTA - PDA: Postural Sequence

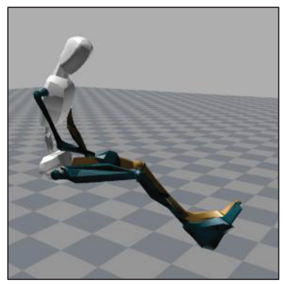
Postural Sequence:	Outside Scan Confined (FP)
NIGHT	
Participant # (Sample Graphs):	FP03
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
More scanning looks than Outside Scan Regular, with more views to the side and steeply down for landing position. More frequent scanning at night.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

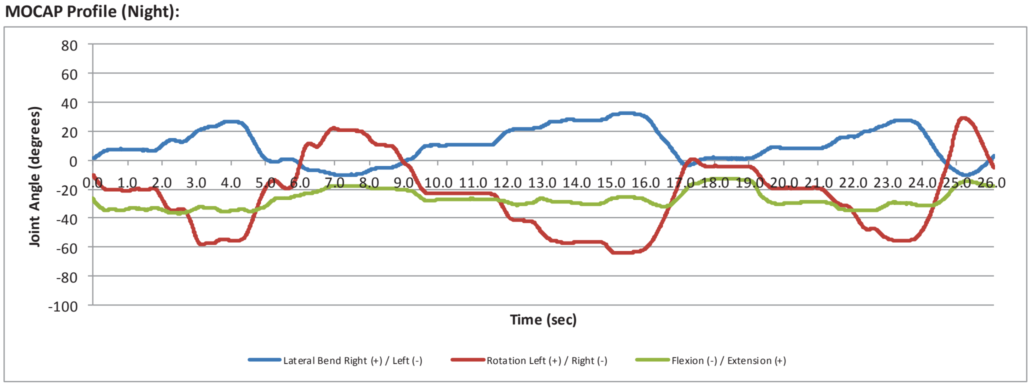
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



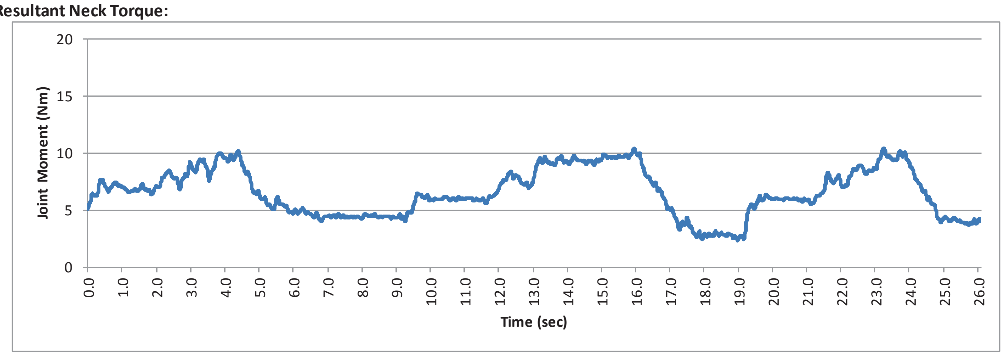
Posture Duration:	19.532	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

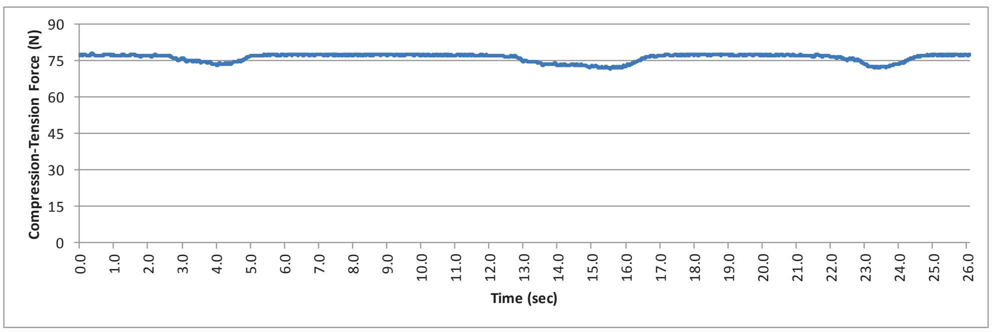
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	76.95	74.84	1462.43	Right Lateral Bend	27.32	16.91
Tension (N)	NA	NA	NA	Left Lateral Bend	-6.86	-3.55
Anterior Shear (N)	12.81	6.44	81.22	Left Axial Rotation	28.12	15.28
Posterior Shear (N)	-12.43	-7.25	-75.27	Right Axial Rotation	-48.58	-31.37
Right Lateral Shear (N)	9.70	3.88	32.16	Extension	NA	NA
Left Lateral Shear (N)	-14.03	-5.99	-67.41	Flexion	-43.85	-28.70
Torque (Resultant) (Nm)	8.11	6.09	102.07			
Right Lateral Moment (+Mx) (Nm	2.00	0.96	3.93			
Left Lateral Moment (-Mx) (Nm)	-5.78	-3.45	-55.69			
Left Axial Moment (+My) (Nm)	1.50	0.71	7.74			
Right Axial Moment (-My) (Nm)	-1.08	-0.29	-2.48			
Extension Moment (+Mz) (Nm)	7.35	4.83	94.38			
Flexion Moment (-Mz) (Nm)	NA	NA	NA			

Outside Scan Confined – Night

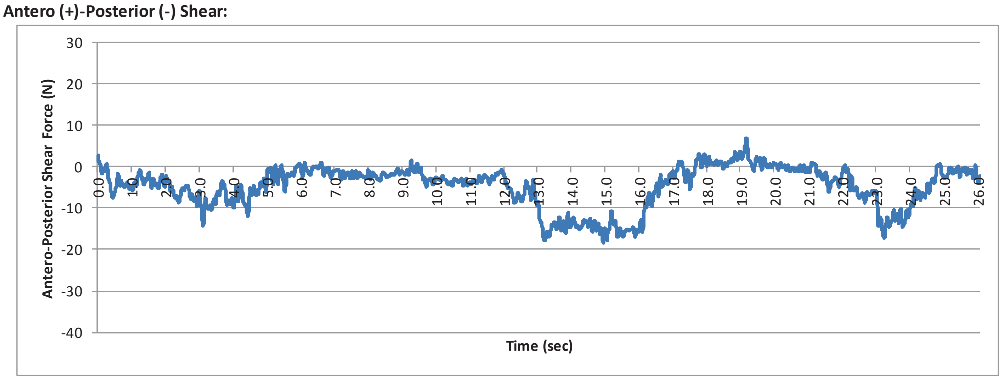
Resultant Neck Torque:



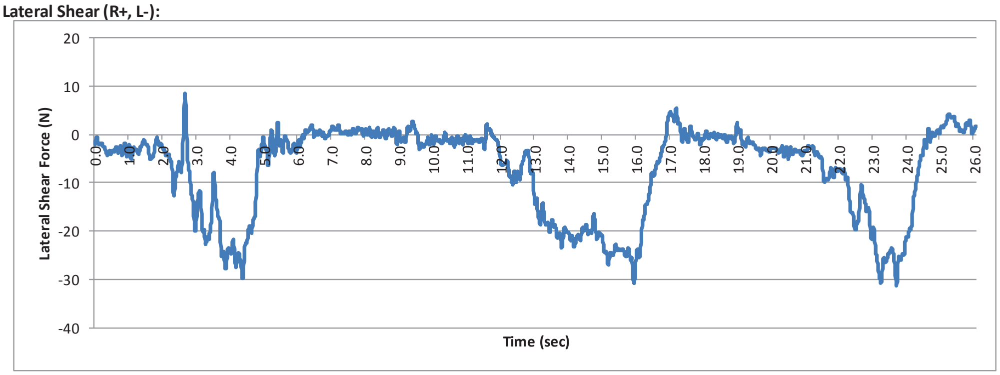
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



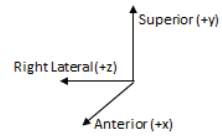
Lateral Shear (R+, L-):



Outside Scan Regular - Day

Griffon MFTA - PDA: Postural Sequence

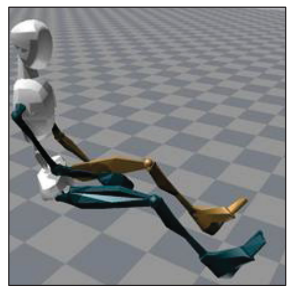
Postural Sequence:	Outside Scan Regular (FP)
DAY	
Participant # (Sample Graphs):	FP04
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
Observing through windscreen to the front and partially down and to the side. Night involves much more scanning due to lack of referents. (assumes not confined space)	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

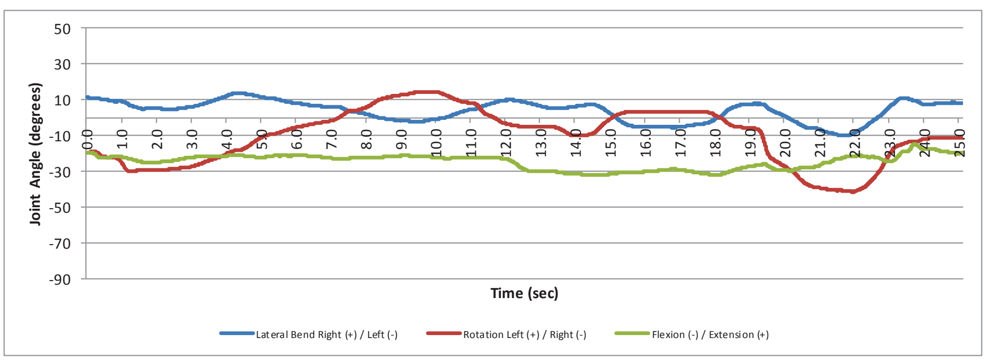
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



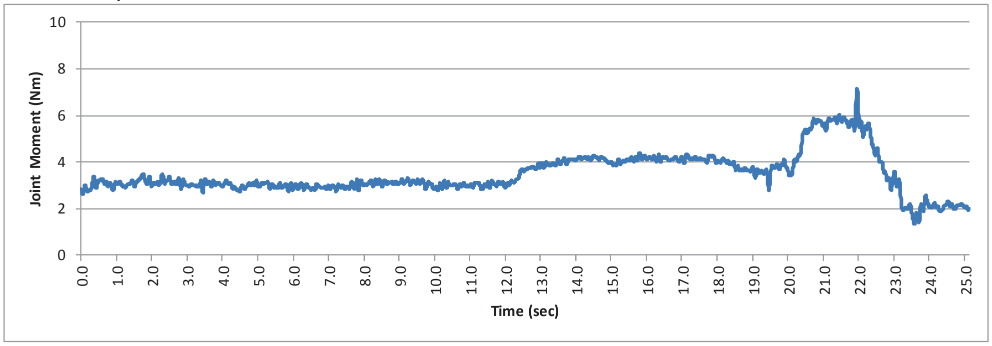
Posture Duration:	27.554	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

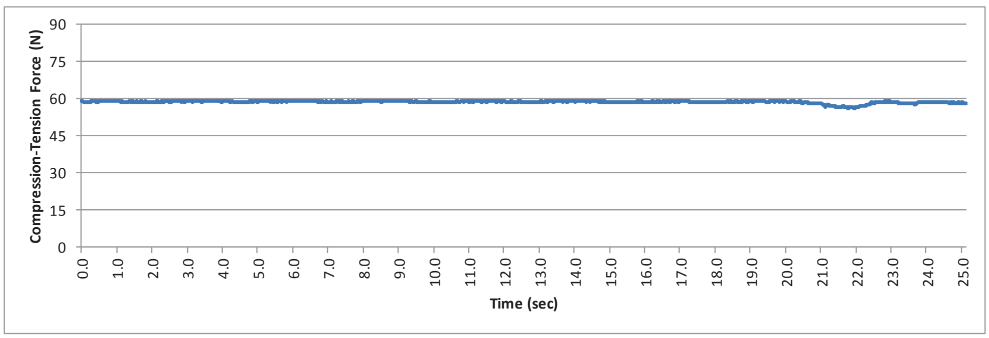
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	59.63	59.19	1631.39	Right Lateral Bend	14.91	5.66
Tension (N)	NA	NA	NA	Left Lateral Bend	-12.17	-6.12
Anterior Shear (N)	9.04	4.10	72.19	Left Axial Rotation	25.50	18.86
Posterior Shear (N)	-18.01	-2.09	-27.73	Right Axial Rotation	-45.70	-18.97
Right Lateral Shear (N)	6.22	2.47	38.56	Extension	NA	NA
Left Lateral Shear (N)	-5.92	-1.57	-18.72	Flexion	-30.39	-21.29
Torque (Resultant) (Nm)	3.55	3.48	54.80			
Right Lateral Moment (+Mx) (Nm)	2.22	1.04	13.52			
Left Lateral Moment (-Mx) (Nm)	-2.91	-0.91	-13.34			
Left Axial Moment (+My) (Nm)	0.39	0.10	0.96			
Right Axial Moment (-My) (Nm)	-0.51	-0.14	-2.54			
Extension Moment (+Mz) (Nm)	5.41	3.16	86.99			
Flexion Moment (-Mz) (Nm)	-0.02	-0.02	0.00			

Outside Scan Regular – Day

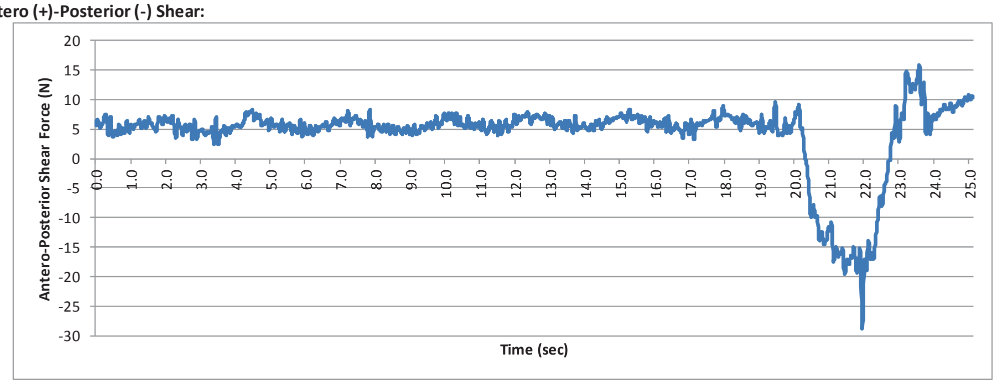
Resultant Neck Torque:



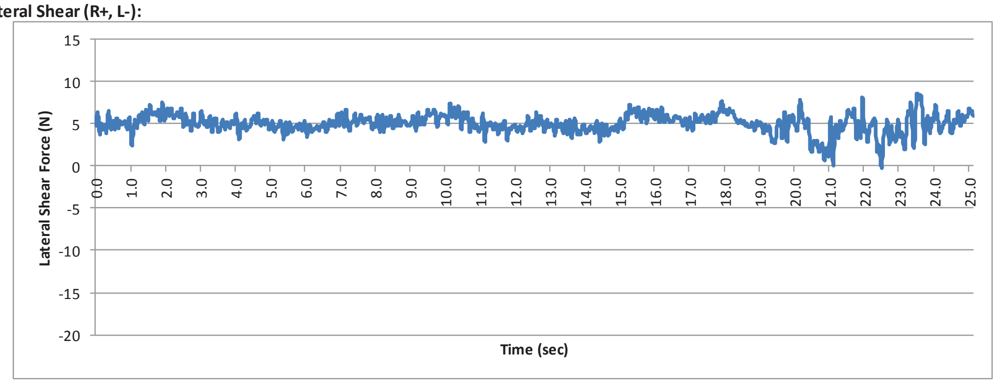
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



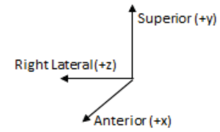
Lateral Shear (R+, L-):



Outside Scan Regular - Night

Griffon MFTA - PDA: Postural Sequence

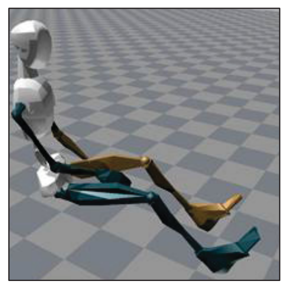
Postural Sequence:	Outside Scan Regular (FP)
NIGHT	
Participant # (Sample Graphs):	FP04
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
Observing through windscreen to the front and partially down and to the side. Night involves much more scanning due to lack of referents. (assumes not confined space)	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

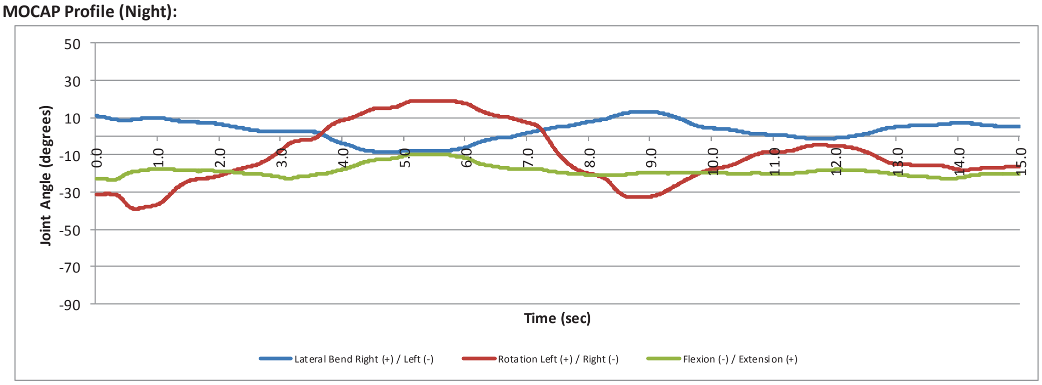
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	18.213	seconds

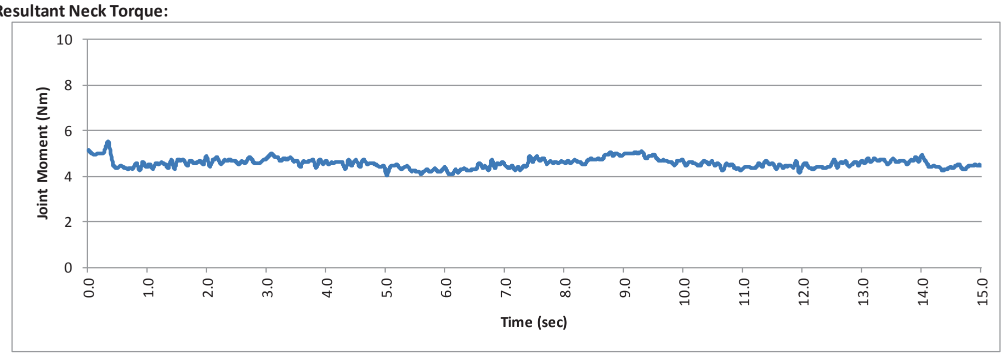
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	75.58	75.44	1374.58
Tension (N)	NA	NA	NA
Anterior Shear (N)	7.36	3.78	62.57
Posterior Shear (N)	-2.70	-0.64	-1.42
Right Lateral Shear (N)	8.16	4.03	68.53
Left Lateral Shear (N)	-1.13	-0.62	-1.51
Torque (Resultant) (Nm)	3.15	3.71	38.66
Right Lateral Moment (+Mx) (Nm	2.99	1.21	11.35
Left Lateral Moment (-Mx) (Nm)	-2.30	-1.01	-8.87
Left Axial Moment (+My) (Nm)	0.32	0.11	0.44
Right Axial Moment (-My) (Nm)	-0.74	-0.22	-3.07
Extension Moment (+Mz) (Nm)	5.32	3.47	60.12
Flexion Moment (-Mz) (Nm)	-1.49	-0.75	-2.64

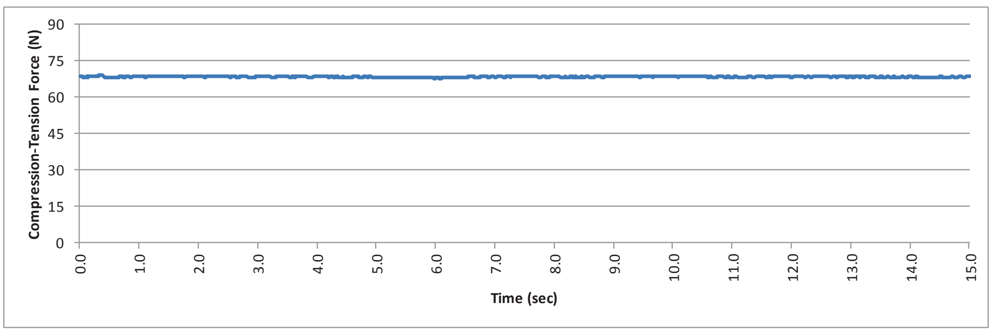
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	11.80	5.63
Left Lateral Bend	-9.66	-4.99
Left Axial Rotation	34.61	18.28
Right Axial Rotation	-35.88	-17.21
Extension	2.71	1.73
Flexion	-27.41	-17.88

Outside Scan Regular - Night

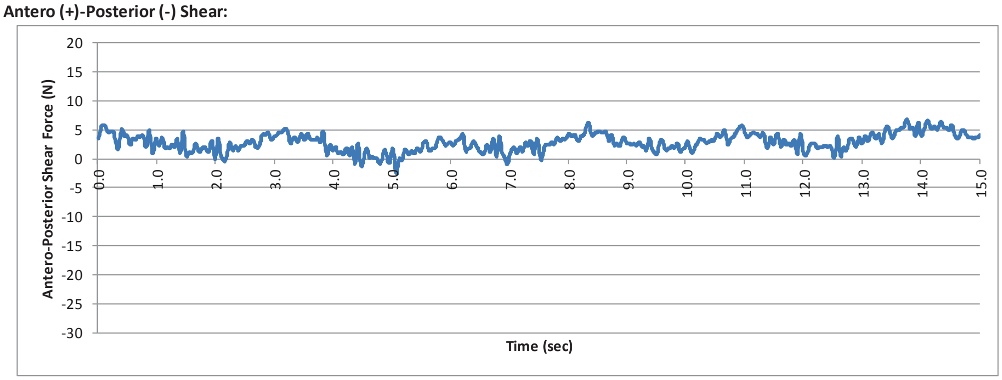
Resultant Neck Torque:



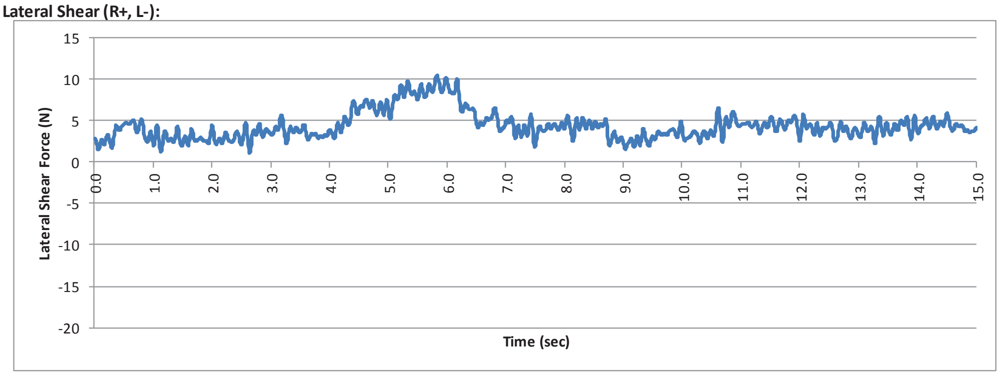
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



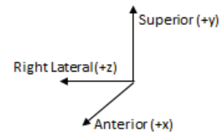
Lateral Shear (R+, L-):



Outside Scan Wide - Day

Griffon MFTA - PDA: Postural Sequence

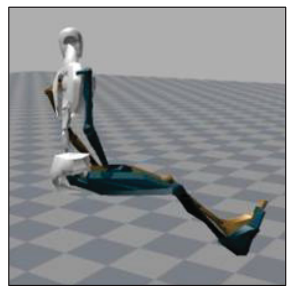
Postural Sequence:	Outside Scan Wide (FP)
DAY	
Participant # (Sample Graphs):	FP05
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
Involves checking front, sides, and both back windows in a dangerous confined space when NFP is less experienced. Less common.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

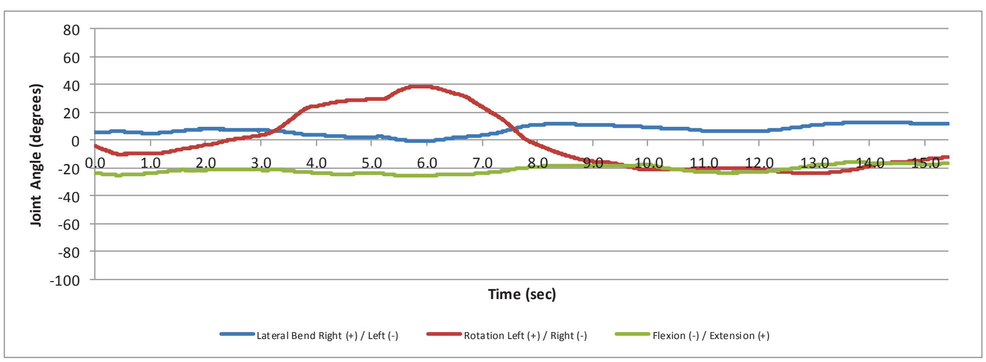
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	16.396	seconds

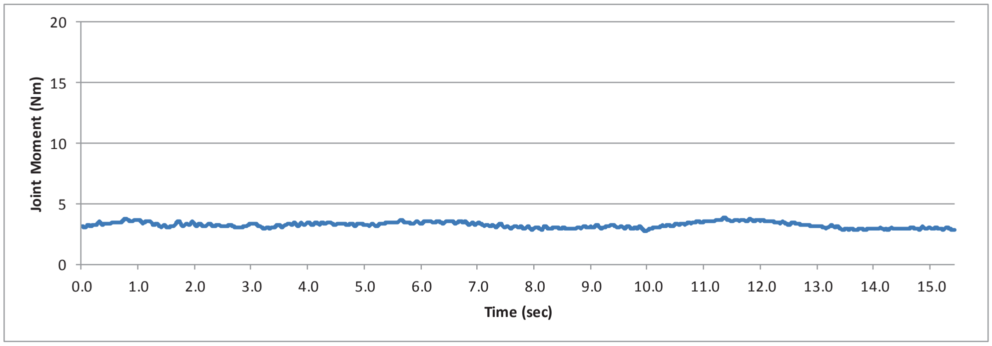
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	59.73	58.22	955.12
Tension (N)	NA	NA	NA
Anterior Shear (N)	12.85	4.50	53.64
Posterior Shear (N)	-32.45	-10.98	-85.35
Right Lateral Shear (N)	16.11	4.15	34.76
Left Lateral Shear (N)	-15.48	-5.64	-45.31
Torque (Resultant) (Nm)	6.68	4.64	65.27
Right Lateral Moment (+Mx) (Nm)	4.19	2.27	12.12
Left Lateral Moment (-Mx) (Nm)	-4.23	-2.06	-22.78
Left Axial Moment (+My) (Nm)	1.52	0.53	5.87
Right Axial Moment (-My) (Nm)	-0.72	-0.14	-0.72
Extension Moment (+Mz) (Nm)	6.23	3.85	61.08
Flexion Moment (-Mz) (Nm)	-1.84	-0.79	-1.27

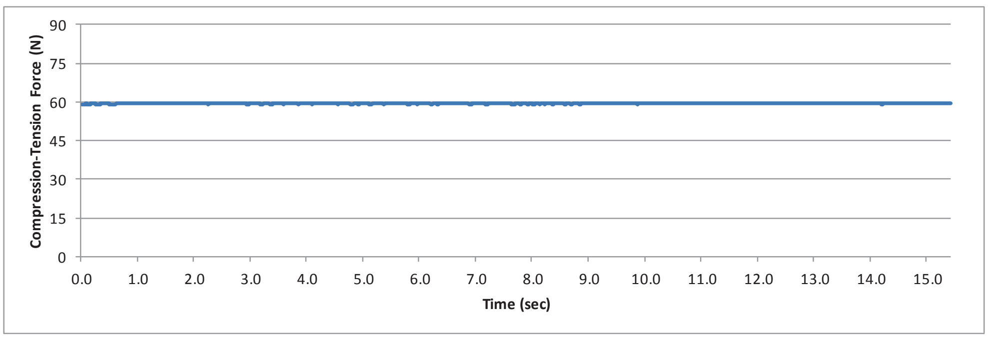
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	19.30	10.82
Left Lateral Bend	-16.01	-11.60
Left Axial Rotation	55.00	34.12
Right Axial Rotation	-46.49	-29.35
Extension	1.59	0.98
Flexion	-36.87	-24.20

Outside Scan Wide – Day

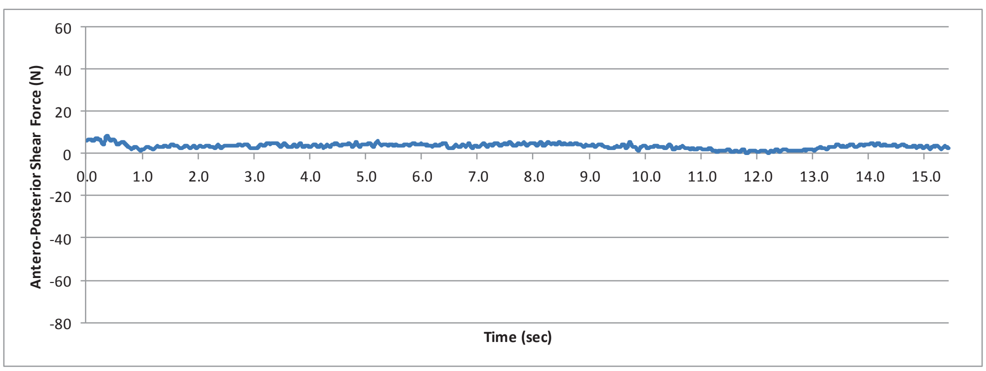
Resultant Neck Torque:



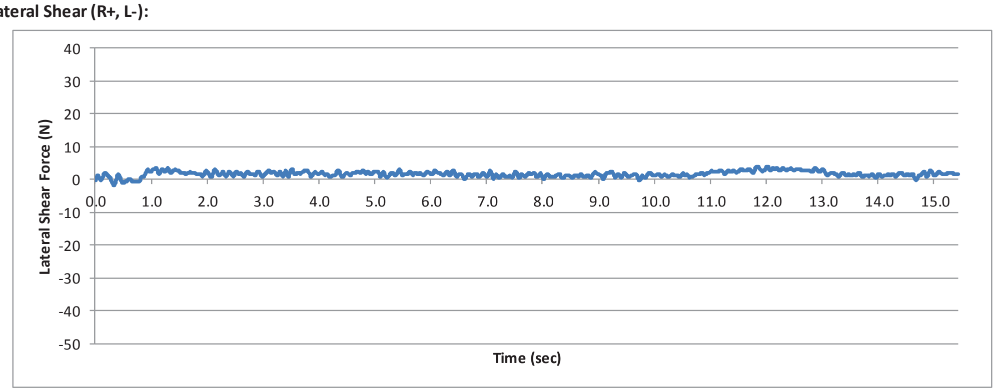
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



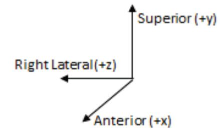
Lateral Shear (R+, L-):



Outside Scan Wide - Night

Griffon MFTA - PDA: Postural Sequence

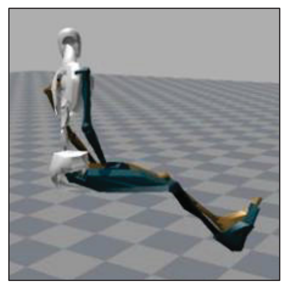
Postural Sequence:	Outside Scan Wide (FP)
NIGHT	
Participant # (Sample Graphs):	FP05
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Involves checking front, sides, and both back windows in a dangerous confined space when NFP is less experienced. Less common.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

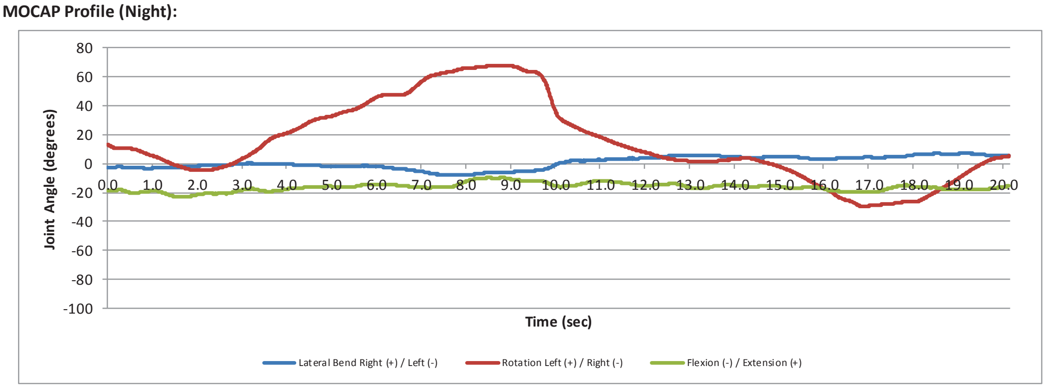
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	15.655	seconds

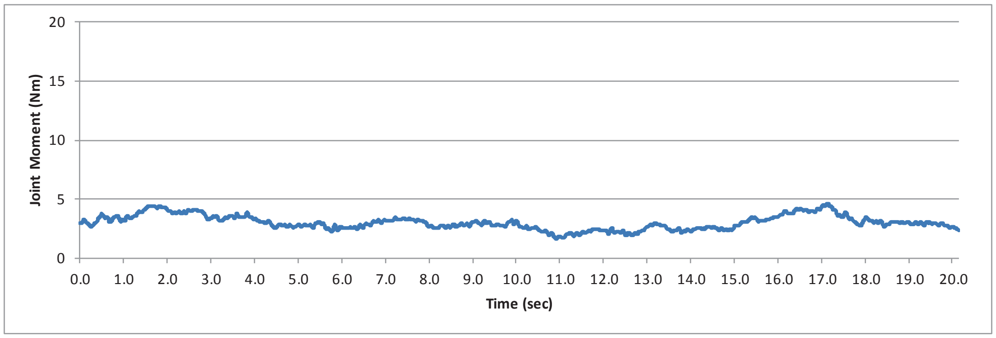
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	77.13	72.48	1135.27
Tension (N)	NA	NA	NA
Anterior Shear (N)	15.19	4.98	40.06
Posterior Shear (N)	-35.86	-17.14	-130.66
Right Lateral Shear (N)	19.49	7.71	66.24
Left Lateral Shear (N)	-22.32	-7.26	-51.36
Torque (Resultant) (Nm)	7.26	5.82	65.17
Right Lateral Moment (+Mx) (Nm	4.36	2.02	14.25
Left Lateral Moment (-Mx) (Nm)	-5.34	-3.01	-25.94
Left Axial Moment (+My) (Nm)	2.13	0.82	5.51
Right Axial Moment (-My) (Nm)	-1.78	-0.55	-4.94
Extension Moment (+Mz) (Nm)	8.09	4.79	75.09
Flexion Moment (-Mz) (Nm)	NA	NA	NA

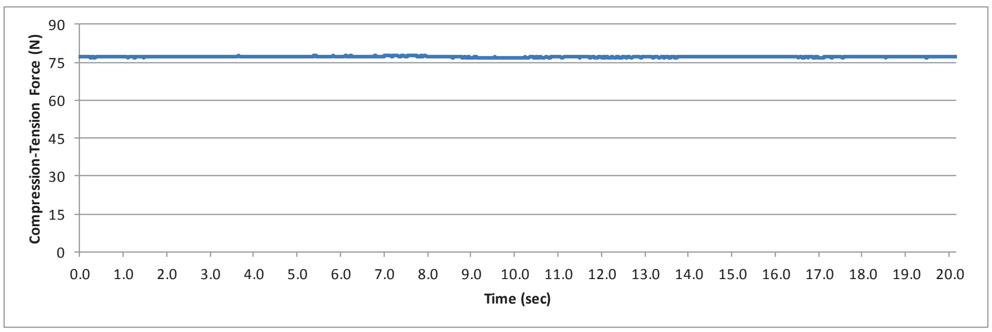
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	21.71	13.79
Left Lateral Bend	-11.17	-7.67
Left Axial Rotation	54.63	31.68
Right Axial Rotation	-53.14	-33.06
Extension	7.52	3.89
Flexion	-39.11	-23.29

Outside Scan Wide - Night

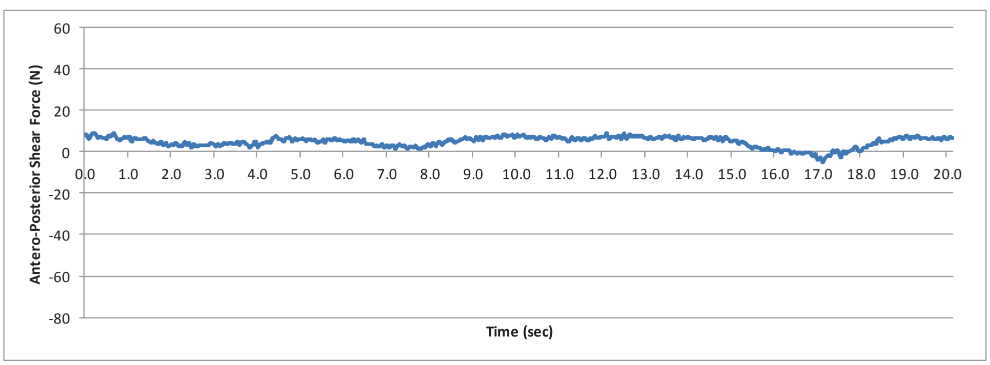
Resultant Neck Torque:



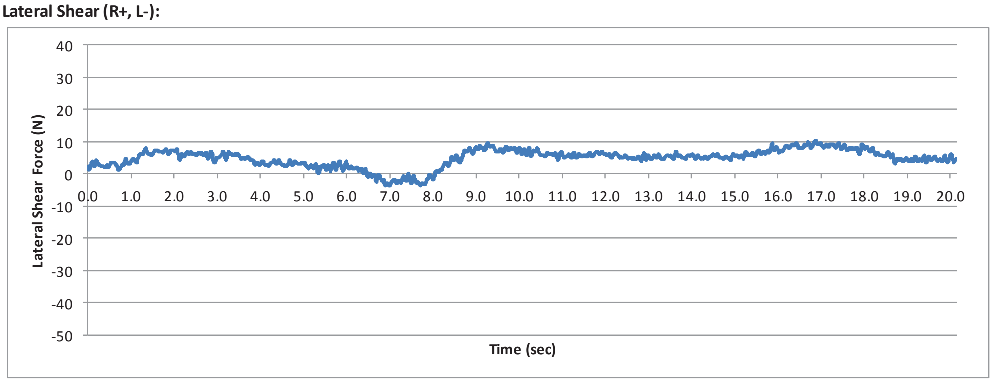
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



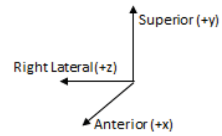
Lateral Shear (R+, L-):



Rapid Scanning – Day

Griffon MFTA - PDA: Postural Sequence

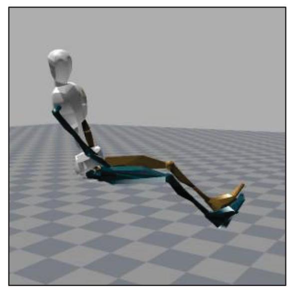
Postural Sequence:	Rapid Scanning (FP)
DAY	
Participant # (Sample Graphs):	FP03
Role:	Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
The FP receives signal of or observes an immediate threat and rapidly scans to locate the threat.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

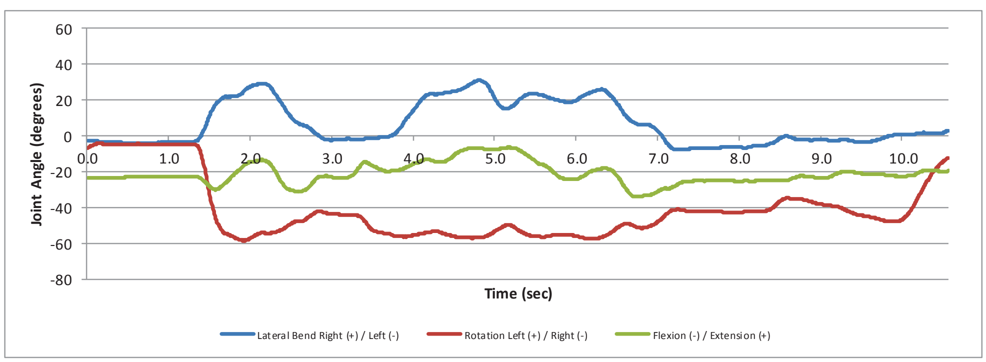
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



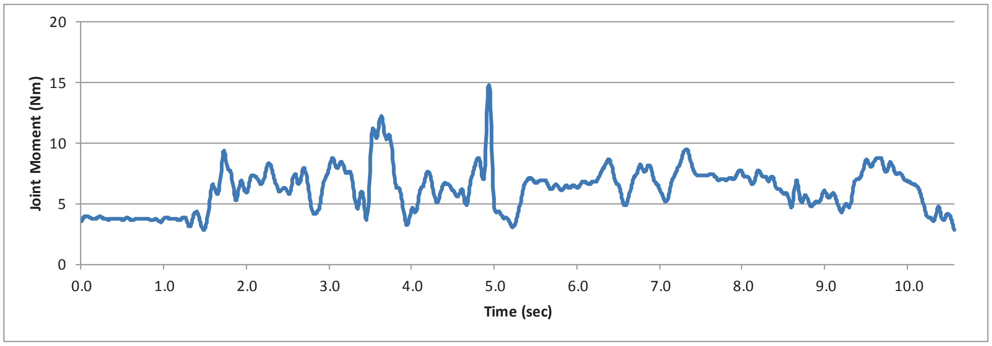
Posture Duration:	14.979	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

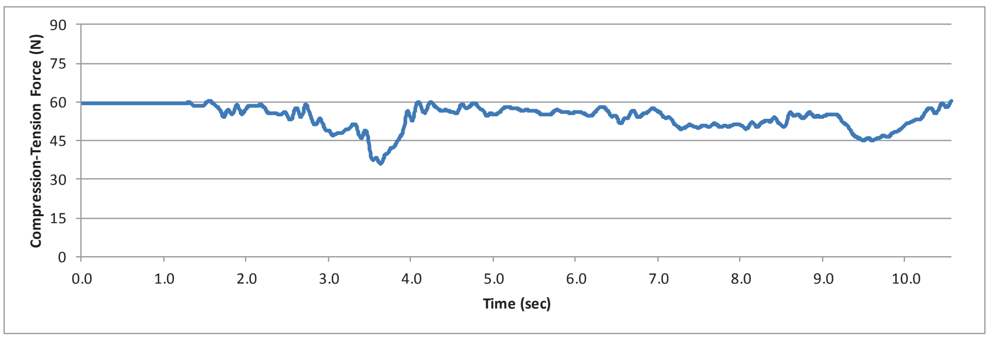
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	60.00	57.67	864.34	Right Lateral Bend	24.82	9.53
Tension (N)	NA	NA	NA	Left Lateral Bend	-7.20	-6.62
Anterior Shear (N)	22.68	6.39	76.45	Left Axial Rotation	18.58	11.89
Posterior Shear (N)	-29.97	-15.20	-45.93	Right Axial Rotation	-41.20	-31.31
Right Lateral Shear (N)	21.39	4.74	46.87	Extension	NA	NA
Left Lateral Shear (N)	-25.32	-10.75	-54.81	Flexion	-34.02	-23.09
Torque (Resultant) (Nm)	5.01	4.21	36.08			
Right Lateral Moment (+Mx) (Nm)	2.69	1.08	7.36			
Left Lateral Moment (-Mx) (Nm)	-6.04	-2.36	-19.29			
Left Axial Moment (+My) (Nm)	2.82	0.98	5.28			
Right Axial Moment (-My) (Nm)	-1.61	-0.31	-2.95			
Extension Moment (+Mz) (Nm)	7.04	3.25	48.11			
Flexion Moment (-Mz) (Nm)	-0.79	-0.49	-0.12			

Rapid Scanning – Day

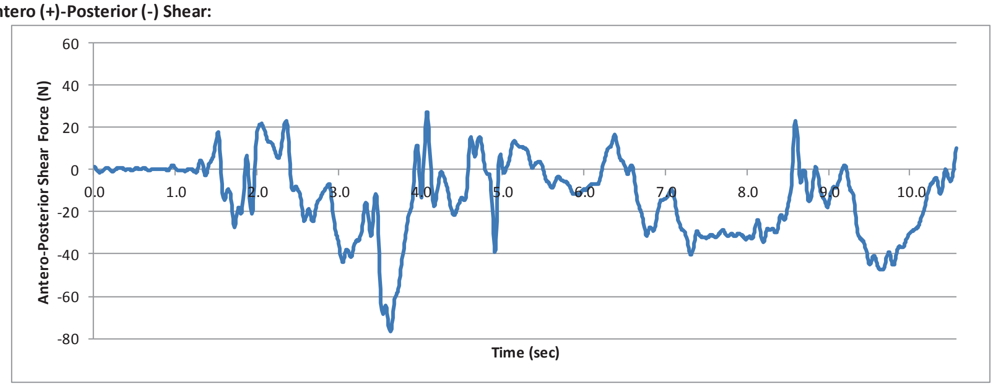
Resultant Neck Torque:



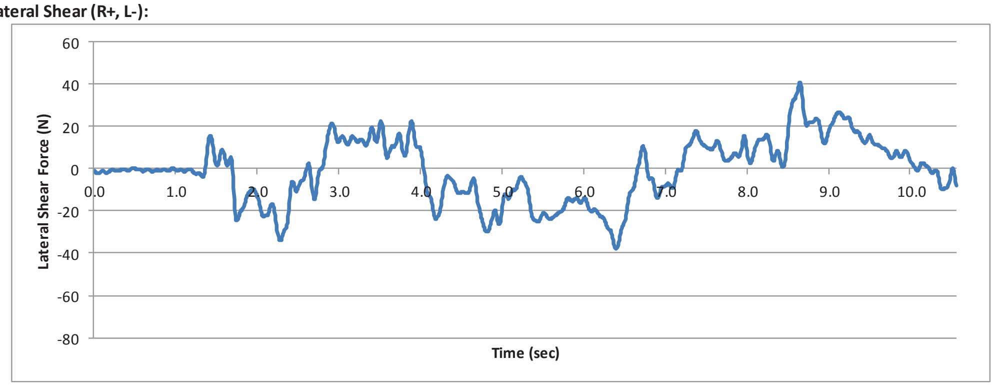
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



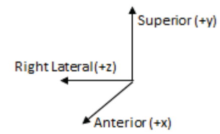
Lateral Shear (R+, L-):



Rapid Scanning – Night

Griffon MFTA - PDA: Postural Sequence

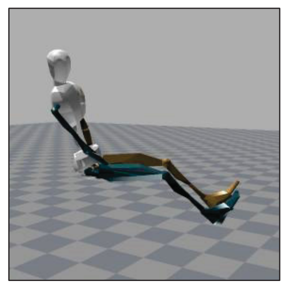
Postural Sequence:	Rapid Scanning (FP)
NIGHT	
Participant # (Sample Graphs):	FP03
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
The FP receives signal of or observes an immediate threat and rapidly scans to locate the threat.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

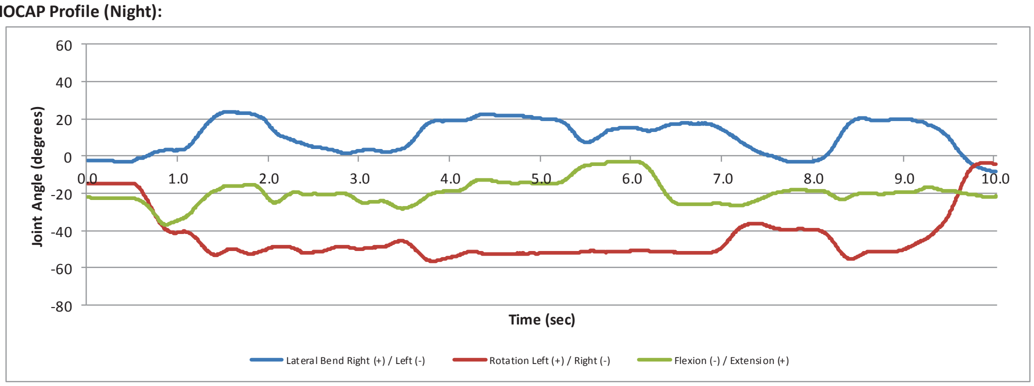
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



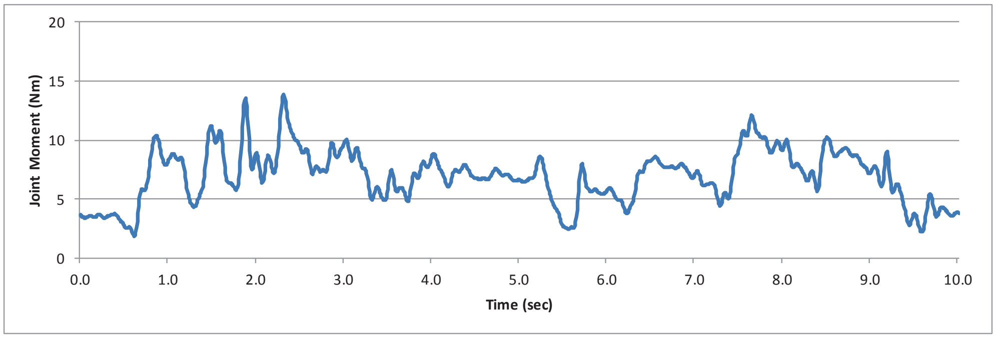
Posture Duration:	10.633	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

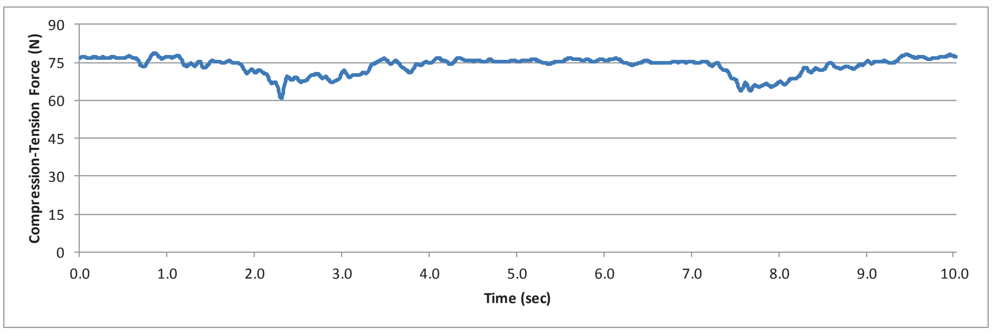
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	77.13	73.25	779.53	Right Lateral Bend	26.06	15.86
Tension (N)	NA	NA	NA	Left Lateral Bend	-11.97	-6.94
Anterior Shear (N)	26.40	10.10	74.03	Left Axial Rotation	35.59	12.34
Posterior Shear (N)	-33.22	-20.16	-66.74	Right Axial Rotation	-54.42	-42.70
Right Lateral Shear (N)	27.03	9.08	48.73	Extension	6.89	3.78
Left Lateral Shear (N)	-28.99	-10.95	-57.76	Flexion	-37.55	-21.69
Torque (Resultant) (Nm)	9.05	5.96	54.40			
Right Lateral Moment (+Mx) (Nm	3.34	1.18	3.52			
Left Lateral Moment (-Mx) (Nm)	-7.89	-3.92	-30.07			
Left Axial Moment (+My) (Nm)	2.87	1.02	6.18			
Right Axial Moment (-My) (Nm)	-2.80	-0.74	-3.39			
Extension Moment (+Mz) (Nm)	9.02	4.08	41.18			
Flexion Moment (-Mz) (Nm)	-2.05	-0.96	-0.79			

Rapid Scanning – Night

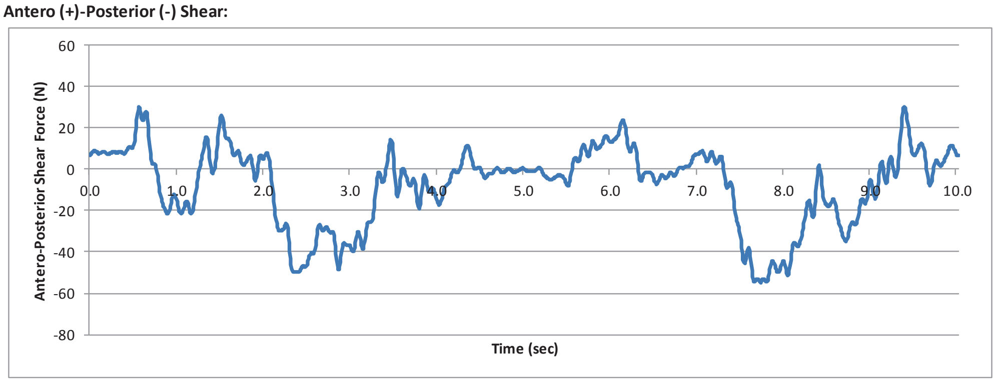
Resultant Neck Torque:



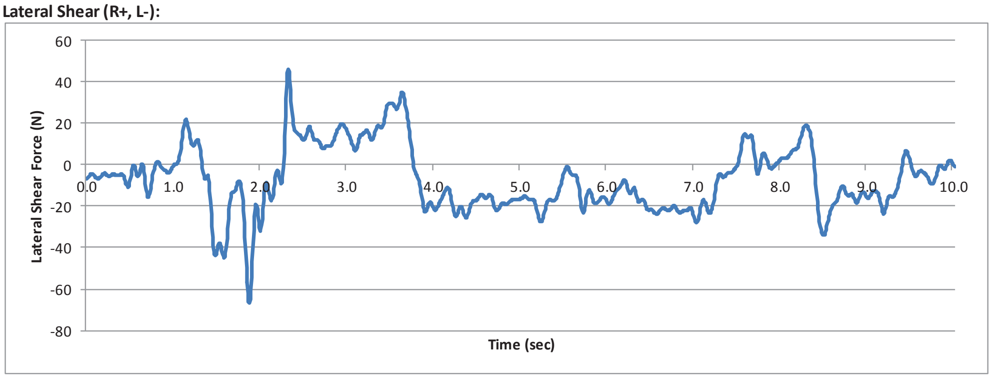
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



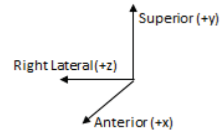
Lateral Shear (R+, L-):



Walking – Day

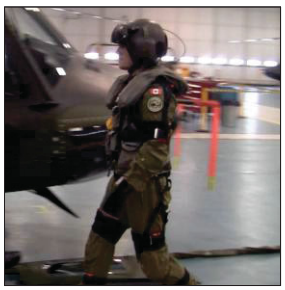
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Walking (FP)
DAY	
Participant # (Sample Graphs):	FP03
Role:	Flying Pilot
Helmet Condition:	Helmet Only

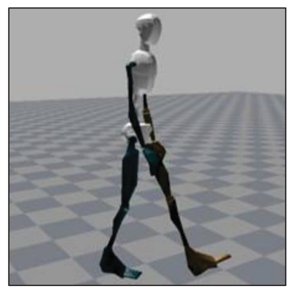


Task Description:	**Equipment Considerations:**
The FP walks to the aircraft. At night, the NVGs may be lowered or raised.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

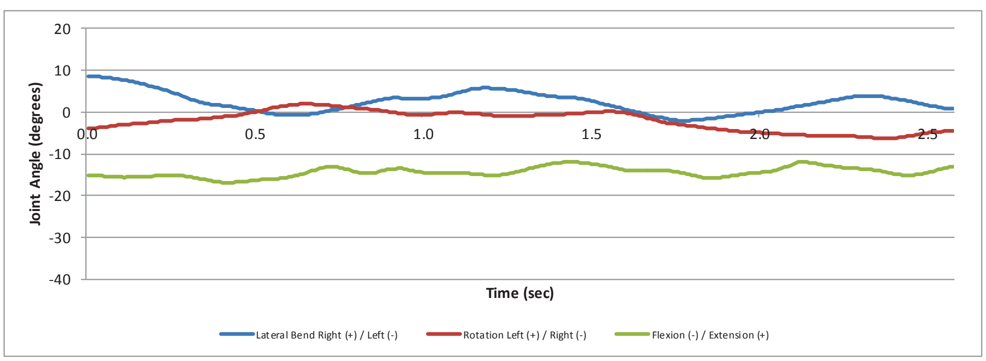


Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	2.745	seconds

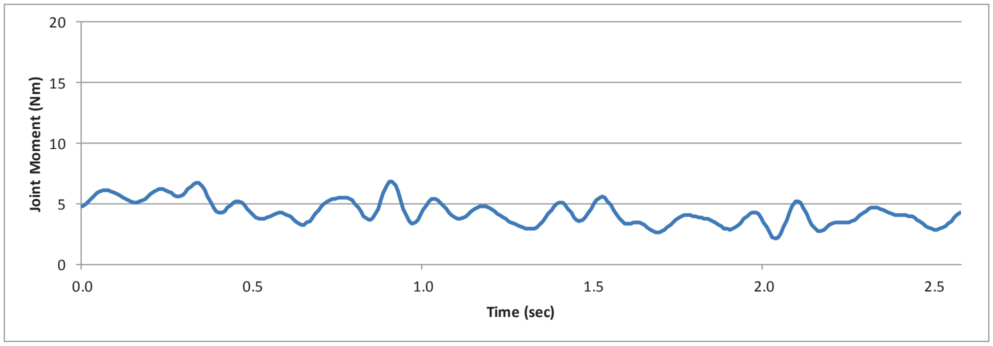
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	64.88	58.73	161.70
Tension (N)	NA	NA	NA
Anterior Shear (N)	27.49	9.62	7.55
Posterior Shear (N)	-38.82	-12.72	-25.05
Right Lateral Shear (N)	22.03	6.14	8.68
Left Lateral Shear (N)	-23.11	-6.35	-8.51
Torque (Resultant) (Nm)	5.52	3.91	7.68
Right Lateral Moment (+Mx) (Nm)	2.40	0.81	0.83
Left Lateral Moment (-Mx) (Nm)	-3.68	-1.27	-2.19
Left Axial Moment (+My) (Nm)	1.06	0.28	0.30
Right Axial Moment (-My) (Nm)	-1.10	-0.31	-0.53
Extension Moment (+Mz) (Nm)	7.20	3.25	8.50
Flexion Moment (-Mz) (Nm)	-1.77	-0.83	-0.14

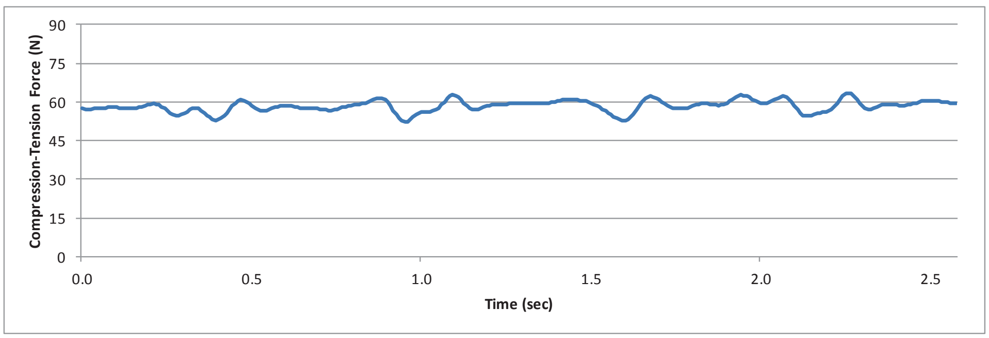
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	6.35	4.27
Left Lateral Bend	-2.65	-1.13
Left Axial Rotation	3.46	2.31
Right Axial Rotation	-12.02	-12.73
Extension	NA	NA
Flexion	-14.86	-12.06

Walking – Day

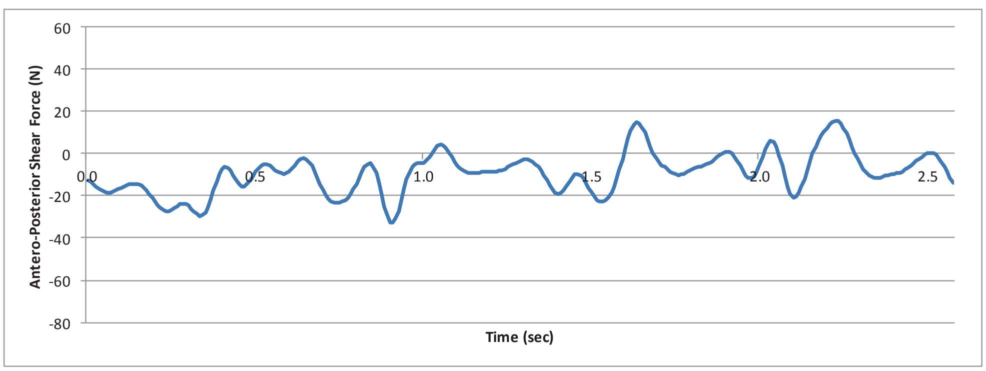
Resultant Neck Torque:



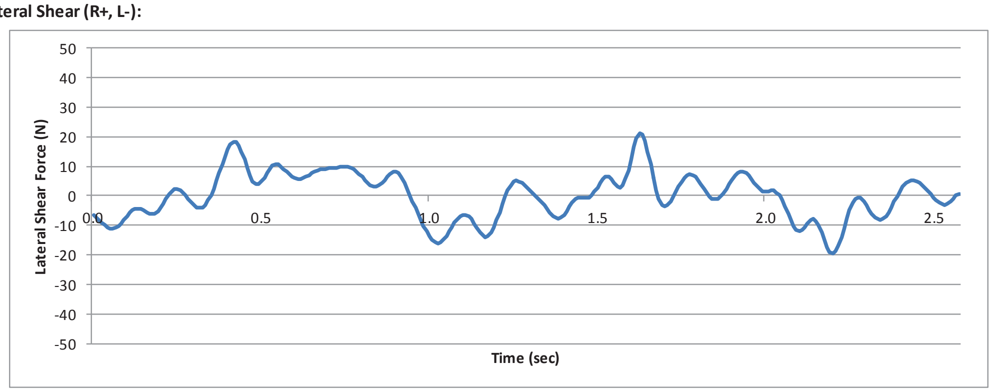
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



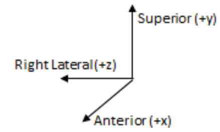
Lateral Shear (R+, L-):



Walking – Night

Griffon MFTA - PDA: Postural Sequence

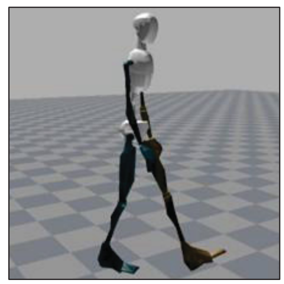
Postural Sequence:	Walking (FP)
NIGHT	
Participant # (Sample Graphs):	FP03
Role:	Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
The FP walks to the aircraft. At night, the NVGs may be lowered or raised.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

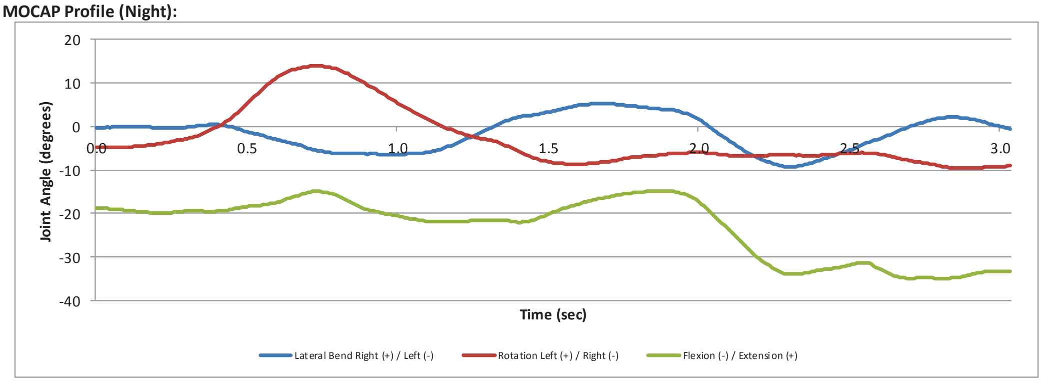
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



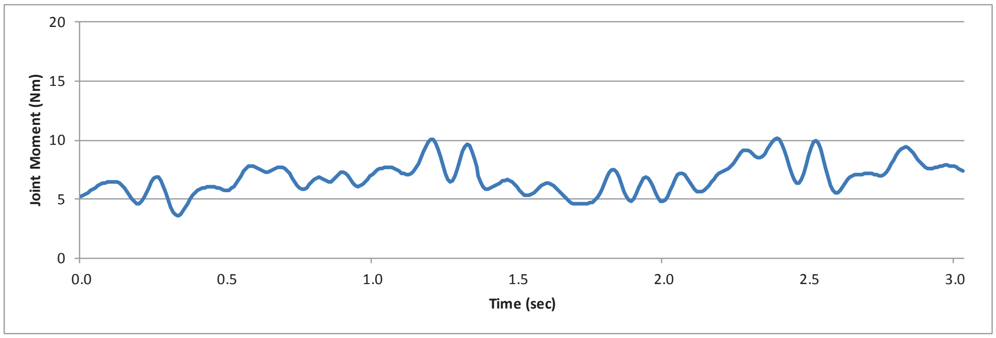
Posture Duration:	2.938	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

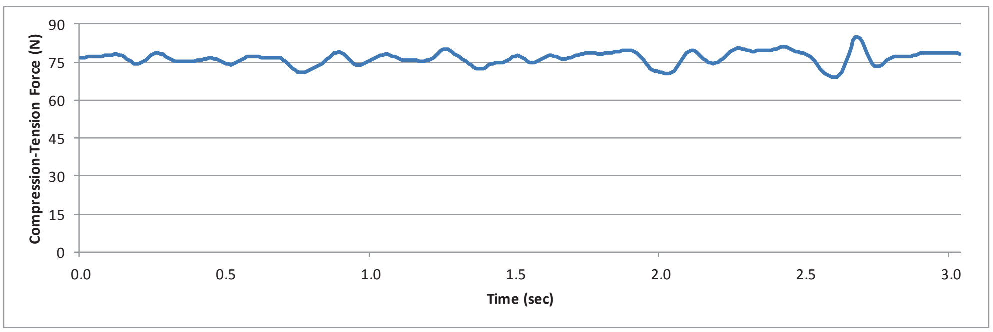
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	84.11	75.36	221.99	Right Lateral Bend	5.56	3.15
Tension (N)	NA	NA	NA	Left Lateral Bend	-6.80	-2.42
Anterior Shear (N)	40.20	11.58	11.49	Left Axial Rotation	8.54	4.80
Posterior Shear (N)	-48.19	-14.24	-27.83	Right Axial Rotation	-13.15	-12.80
Right Lateral Shear (N)	29.58	8.92	13.32	Extension	NA	NA
Left Lateral Shear (N)	-29.13	-8.04	-11.68	Flexion	-18.68	-13.86
Torque (Resultant) (Nm)	8.91	5.24	13.23			
Right Lateral Moment (+Mx) (Nm	3.68	1.28	1.57			
Left Lateral Moment (-Mx) (Nm)	-4.50	-1.47	-2.52			
Left Axial Moment (+My) (Nm)	1.47	0.42	0.56			
Right Axial Moment (-My) (Nm)	-1.33	-0.41	-0.66			
Extension Moment (+Mz) (Nm)	10.13	4.42	12.18			
Flexion Moment (-Mz) (Nm)	-3.10	-1.45	-0.33			

Walking – Night

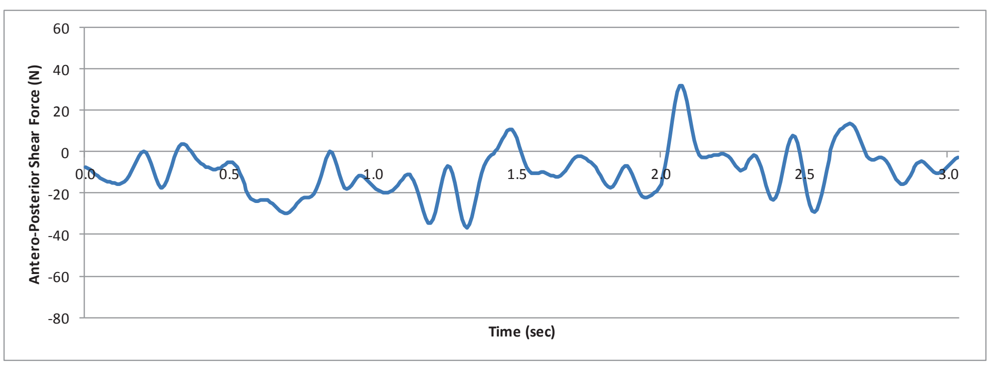
Resultant Neck Torque:



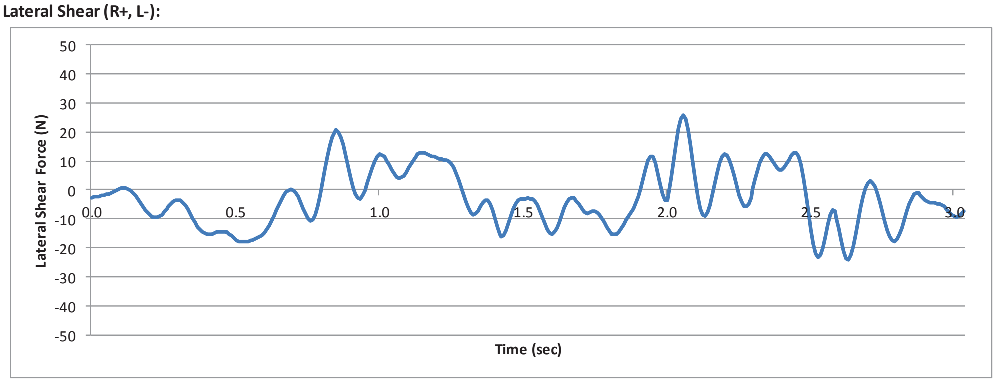
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):



Non-Flying Pilot

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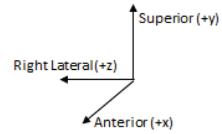
AC Egress - Day

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	AC Egress (NFP)
DAY	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



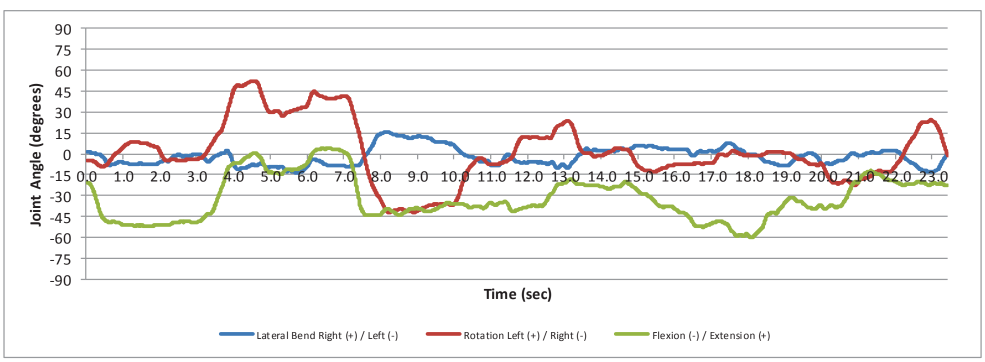
Task Description:	Equipment Considerations:
The NFP disconnects communications (and HUD if night mission), removes restraints and egresses the aircraft through the NFP door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



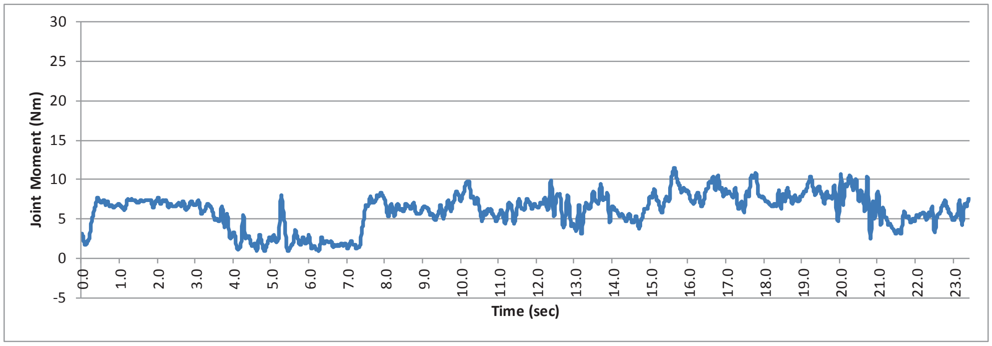
Posture Duration:	26.175	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

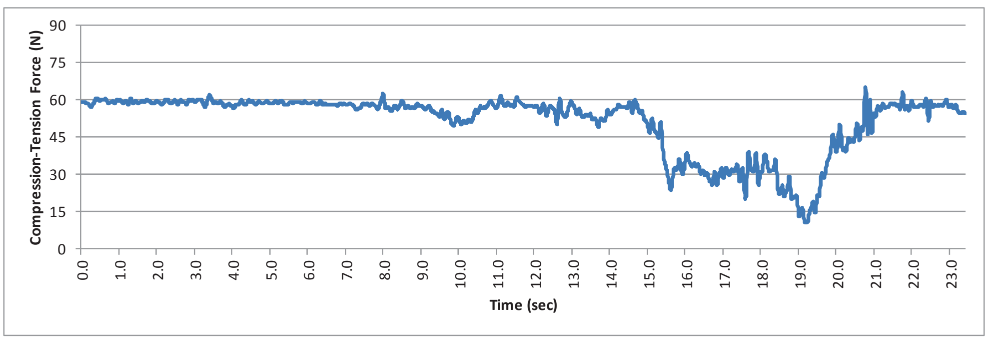
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	70.82	53.85	1409.89	Right Lateral Bend	15.77	5.52
Tension (N)	NA	NA	NA	Left Lateral Bend	-18.41	-6.31
Anterior Shear (N)	45.95	8.33	74.62	Left Axial Rotation	50.89	27.90
Posterior Shear (N)	-77.59	-18.84	-324.45	Right Axial Rotation	-31.45	-13.73
Right Lateral Shear (N)	54.17	9.17	91.23	Extension	3.36	2.12
Left Lateral Shear (N)	-59.21	-10.99	-178.50	Flexion	-60.29	-33.40
Torque (Resultant) (Nm)	13.56	5.94	111.18			
Right Lateral Moment (+Mx) (Nm)	6.91	1.30	15.30			
Left Lateral Moment (-Mx) (Nm)	-6.19	-1.33	-19.19			
Left Axial Moment (+My) (Nm)	6.44	0.93	14.37			
Right Axial Moment (-My) (Nm)	-5.19	-0.74	-7.90			
Extension Moment (+Mz) (Nm)	11.50	5.44	135.96			
Flexion Moment (-Mz) (Nm)	-2.90	-1.17	-1.37			

AC Egress - Day

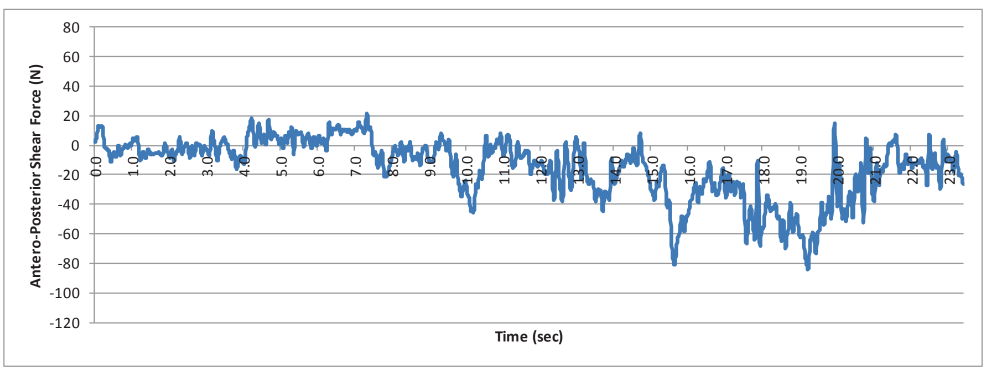
Resultant Neck Torque:



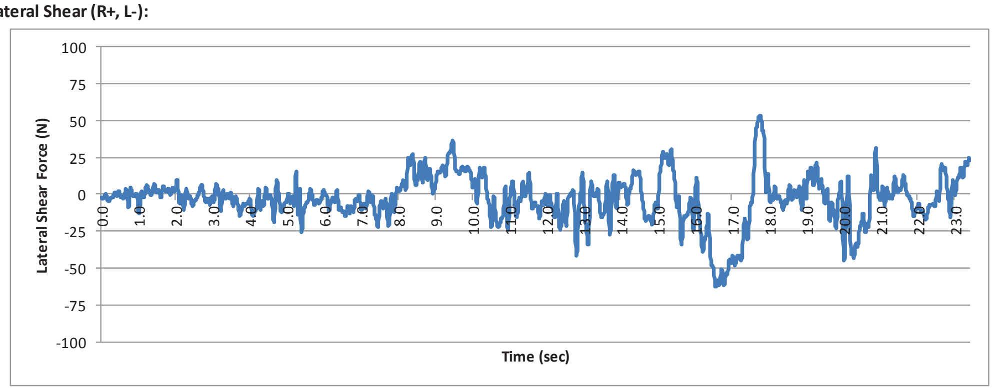
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



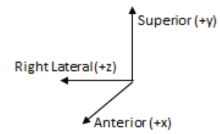
Lateral Shear (R+, L-):



AC Egress - Night

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	AC Egress (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



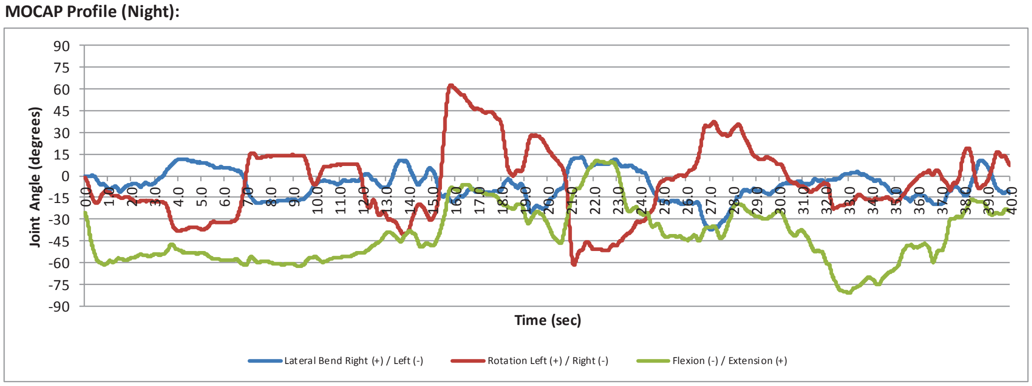
Task Description:	Equipment Considerations:
The NFP disconnects communications (and HUD if night mission), removes restraints and egresses the aircraft through the NFP door.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Night):



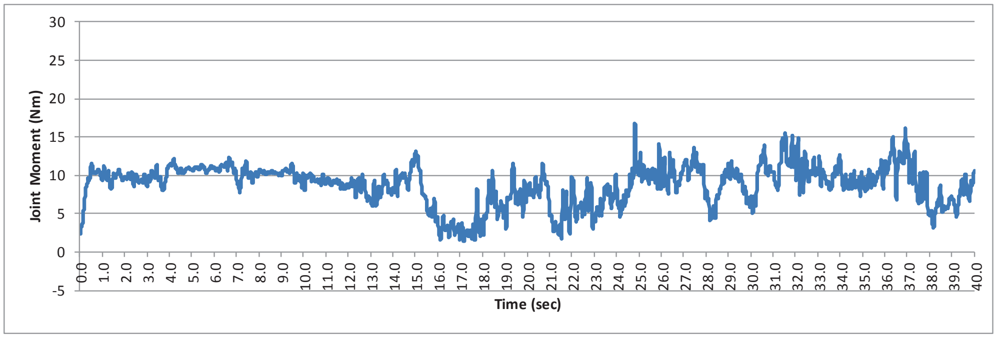
Posture Duration:	38.158	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

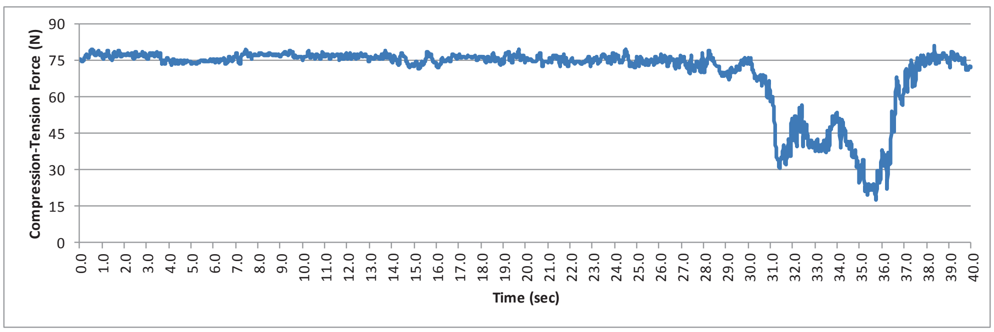
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	84.48	70.32	2683.89	Right Lateral Bend	21.51	8.32
Tension (N)	NA	NA	NA	Left Lateral Bend	-26.13	-11.20
Anterior Shear (N)	44.05	10.21	193.00	Left Axial Rotation	54.69	32.47
Posterior Shear (N)	-100.73	-27.95	-538.27	Right Axial Rotation	-52.08	-21.14
Right Lateral Shear (N)	58.25	8.77	116.95	Extension	7.05	5.64
Left Lateral Shear (N)	-68.76	-13.88	-344.56	Flexion	-74.36	-36.05
Torque (Resultant) (Nm)	7.35	8.19	133.90			
Right Lateral Moment (+Mx) (Nm	8.35	2.07	37.21			
Left Lateral Moment (-Mx) (Nm)	-9.43	-2.36	-47.70			
Left Axial Moment (+My) (Nm)	7.50	1.36	31.79			
Right Axial Moment (-My) (Nm)	-6.76	-0.85	-12.60			
Extension Moment (+Mz) (Nm)	15.20	7.64	266.12			
Flexion Moment (-Mz) (Nm)	-4.96	-2.14	-7.09			

AC Egress - Night

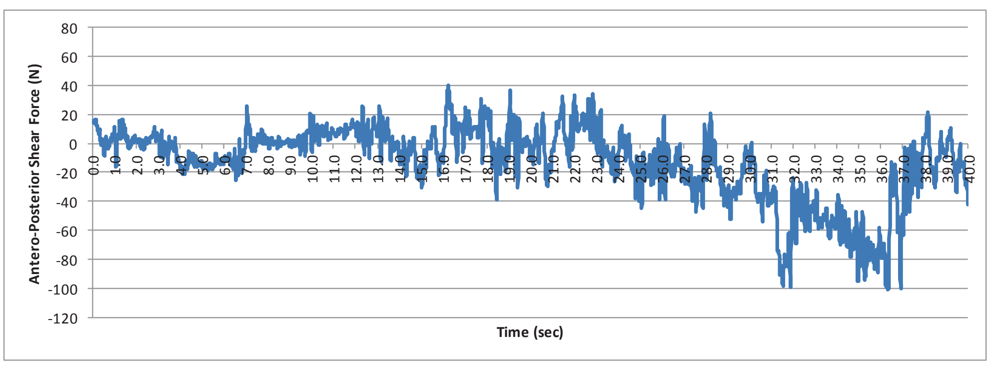
Resultant Neck Torque:



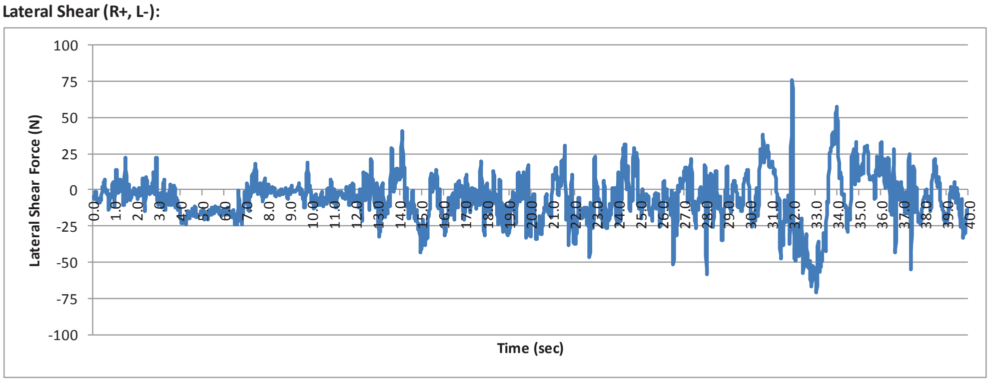
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



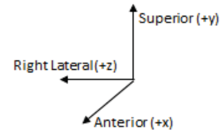
Lateral Shear (R+, L-):



AC Ingress - Day

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	AC Ingress (NFP)
DAY	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



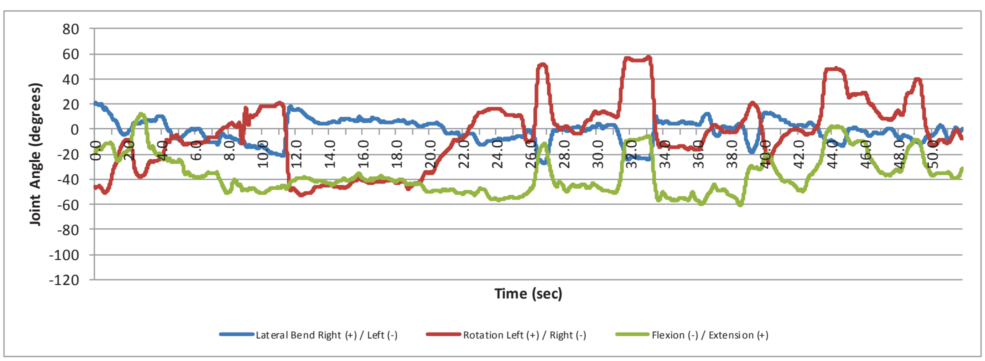
Task Description:	**Equipment Considerations:**
The NFP opens the NFP door of the AC, steps up into seat, adjusts seat and restraints, and finally connects communications. HUD is connected for night missions.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	53.338	seconds

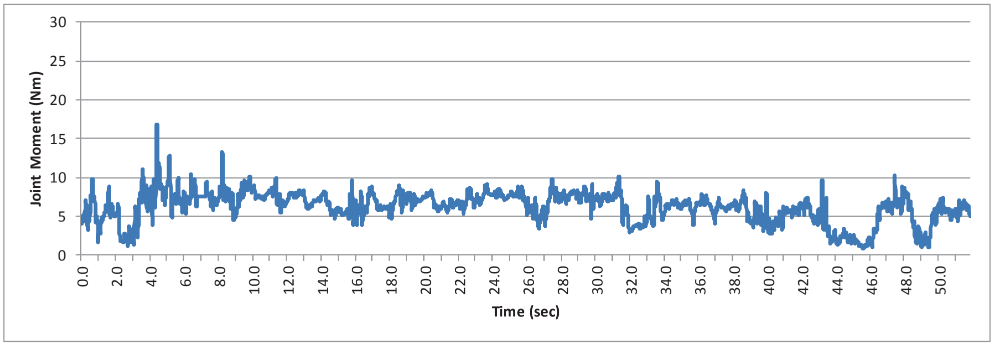
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	68.49	55.59	2961.57
Tension (N)	-13.71	-3.86	-1.38
Anterior Shear (N)	48.04	7.74	199.13
Posterior Shear (N)	-91.61	-16.04	-443.23
Right Lateral Shear (N)	69.07	9.08	205.70
Left Lateral Shear (N)	-48.80	-10.56	-324.32
Torque (Resultant) (Nm)	13.26	6.09	231.93
Right Lateral Moment (+Mx) (Nm)	6.82	1.39	29.37
Left Lateral Moment (-Mx) (Nm)	-7.07	-1.91	-61.80
Left Axial Moment (+My) (Nm)	5.32	0.89	25.32
Right Axial Moment (-My) (Nm)	-6.67	-0.88	-21.91
Extension Moment (+Mz) (Nm)	12.43	5.38	278.16
Flexion Moment (-Mz) (Nm)	-4.04	-1.26	-2.12

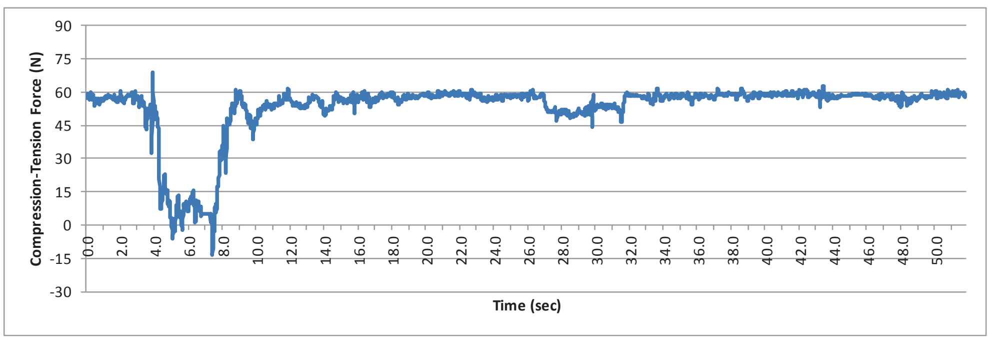
ROM	**Peak** (degrees)	**Mean** (degrees)
Right Lateral Bend	28.73	10.71
Left Lateral Bend	-25.75	-6.99
Left Axial Rotation	55.86	22.30
Right Axial Rotation	-44.47	-19.28
Extension	7.87	3.94
Flexion	-62.12	-38.70

AC Ingress - Day

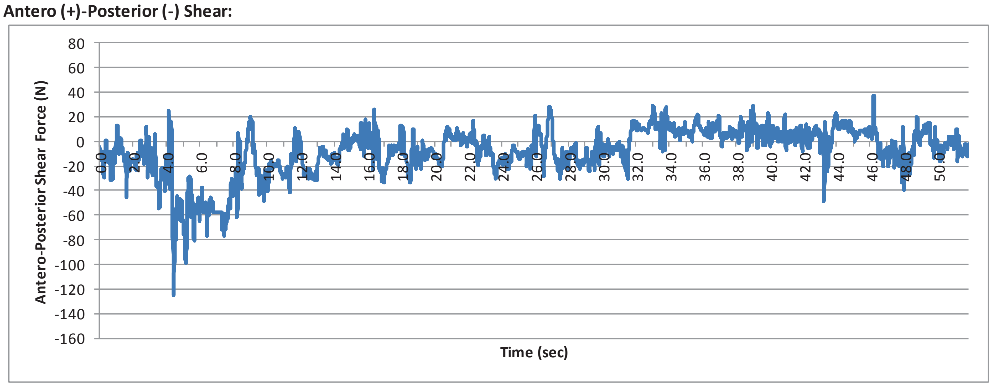
Resultant Neck Torque:



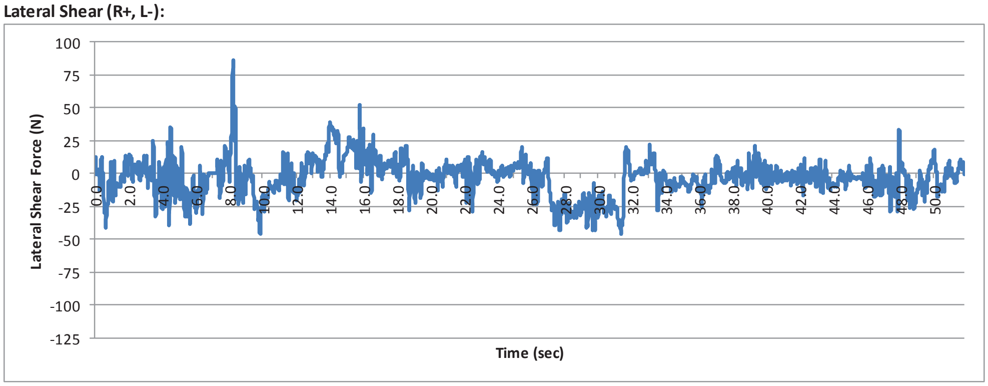
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



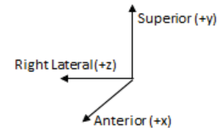
Lateral Shear (R+, L-):



AC Ingress - Night

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	AC Ingress (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



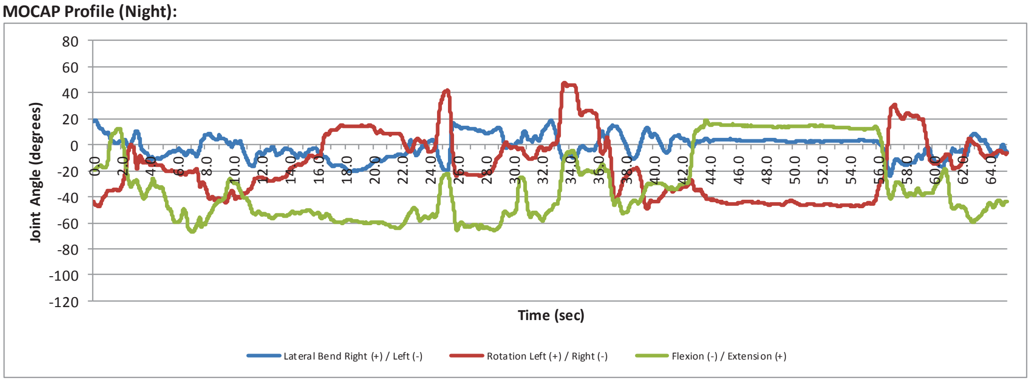
Task Description:	**Equipment Considerations:**
The NFP opens the NFP door of the AC, steps up into seat, adjusts seat and restraints, and finally connects communications. HUD is connected for night missions.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Night):



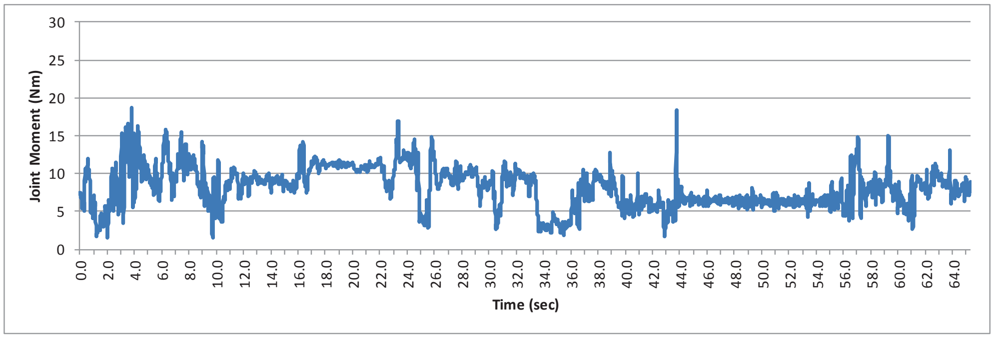
Posture Duration:	78.975	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

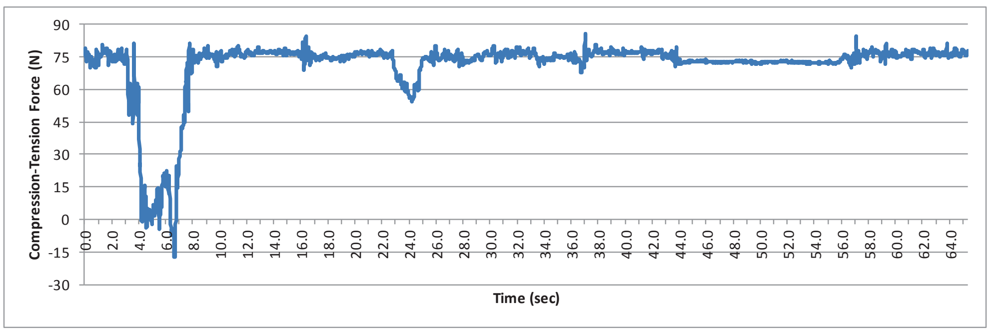
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	87.03	73.10	5757.86	Right Lateral Bend	31.96	6.60
Tension (N)	-17.61	-5.36	-3.44	Left Lateral Bend	-26.74	-9.50
Anterior Shear (N)	70.90	12.38	700.41	Left Axial Rotation	59.57	27.54
Posterior Shear (N)	-117.16	-20.30	-455.08	Right Axial Rotation	-60.62	-22.70
Right Lateral Shear (N)	62.32	9.13	234.33	Extension	14.46	9.65
Left Lateral Shear (N)	-90.64	-14.12	-752.52	Flexion	-68.80	-37.82
Torque (Resultant) (Nm)	13.15	7.34	248.49			
Right Lateral Moment (+Mx) (Nm	7.25	1.65	39.63			
Left Lateral Moment (-Mx) (Nm)	-13.34	-3.71	-204.28			
Left Axial Moment (+My) (Nm)	6.52	1.08	46.69			
Right Axial Moment (-My) (Nm)	-7.62	-0.96	-34.33			
Extension Moment (+Mz) (Nm)	19.45	6.03	388.16			
Flexion Moment (-Mz) (Nm)	-9.50	-3.44	-50.15			

AC Ingress - Night

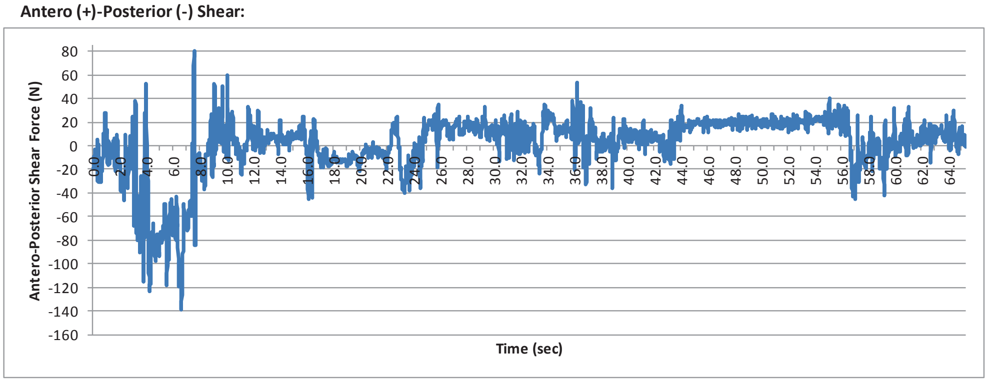
Resultant Neck Torque:



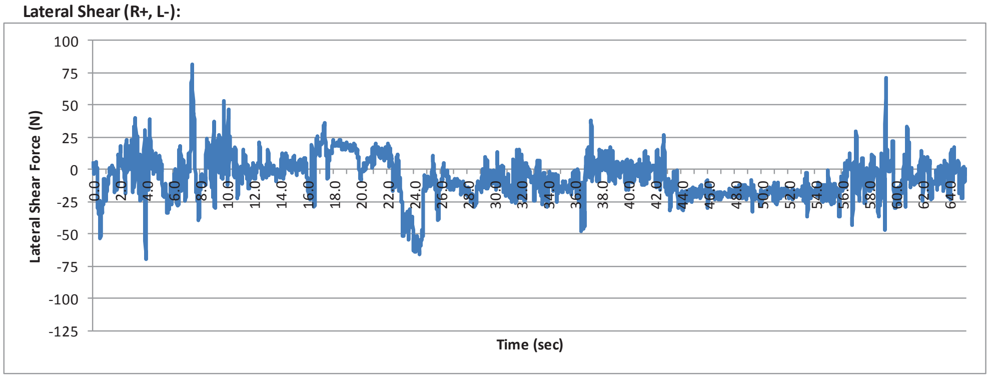
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



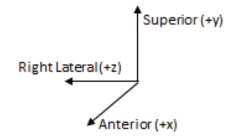
Lateral Shear (R+, L-):



CDU AMS Use - Day

Griffon MFTA - PDA: Postural Sequence

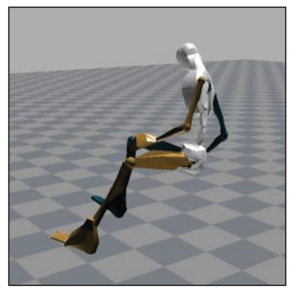
Postural Sequence:	CDU/AMS Use (NFP)
DAY	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
The NFP programs in a new way-point into the CDU and relates these to other information for navigation like bearing and ground speed.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Arial Map - Hard Copy Flight Book

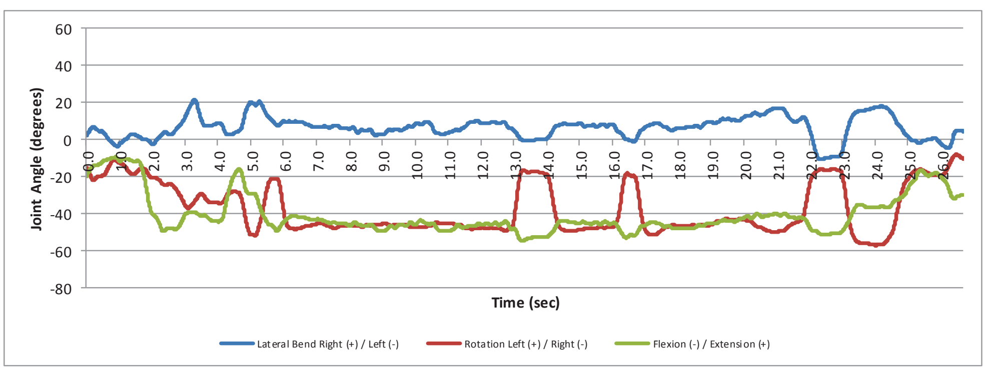
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



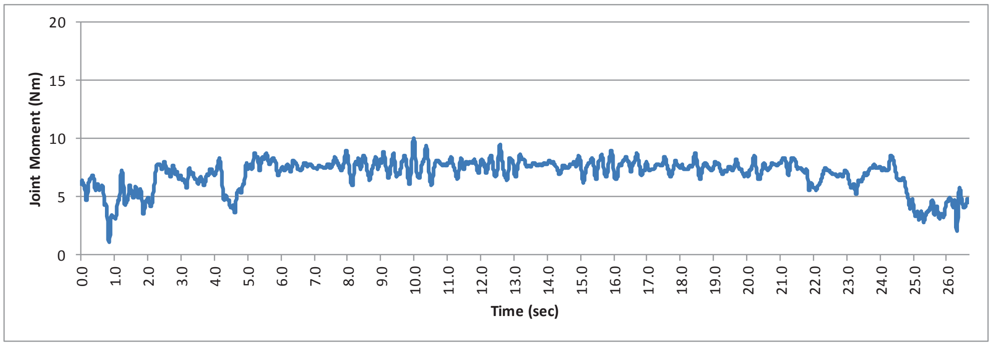
Posture Duration:	27.458	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

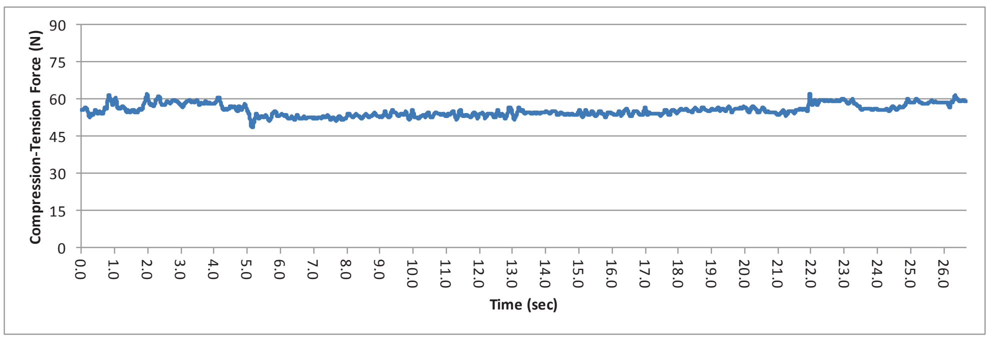
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	60.62	55.79	1532.28	Right Lateral Bend	17.33	6.75
Tension (N)	NA	NA	NA	Left Lateral Bend	-9.58	-2.91
Anterior Shear (N)	16.81	4.84	12.86	Left Axial Rotation	23.97	18.76
Posterior Shear (N)	-28.38	-10.49	-260.16	Right Axial Rotation	-44.01	-32.41
Right Lateral Shear (N)	12.40	6.18	17.54	Extension	2.03	1.32
Left Lateral Shear (N)	-29.13	-17.09	-430.61	Flexion	-49.59	-43.35
Torque (Resultant) (Nm)	6.46	6.90	135.30			
Right Lateral Moment (+Mx) (Nm)	1.59	0.88	2.04			
Left Lateral Moment (-Mx) (Nm)	-4.70	-2.10	-53.82			
Left Axial Moment (+My) (Nm)	2.67	1.67	41.82			
Right Axial Moment (-My) (Nm)	-1.25	-0.50	-1.49			
Extension Moment (+Mz) (Nm)	7.92	6.20	170.36			
Flexion Moment (-Mz) (Nm)	-0.15	-0.09	0.00			

CDU AMS Use - Day

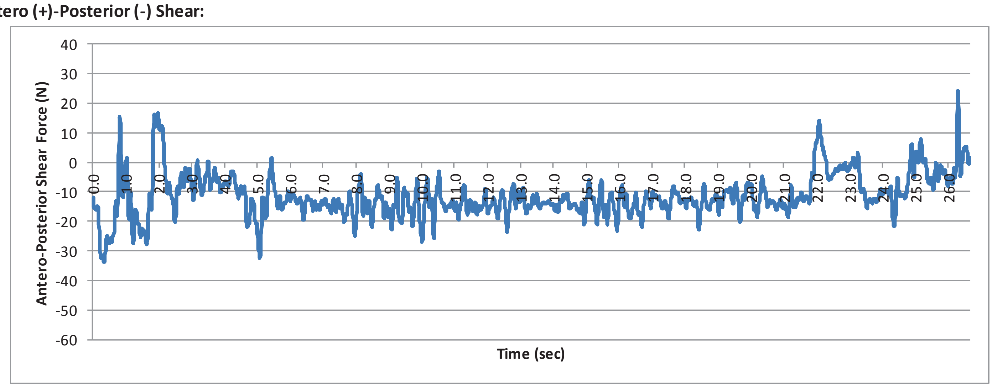
Resultant Neck Torque:



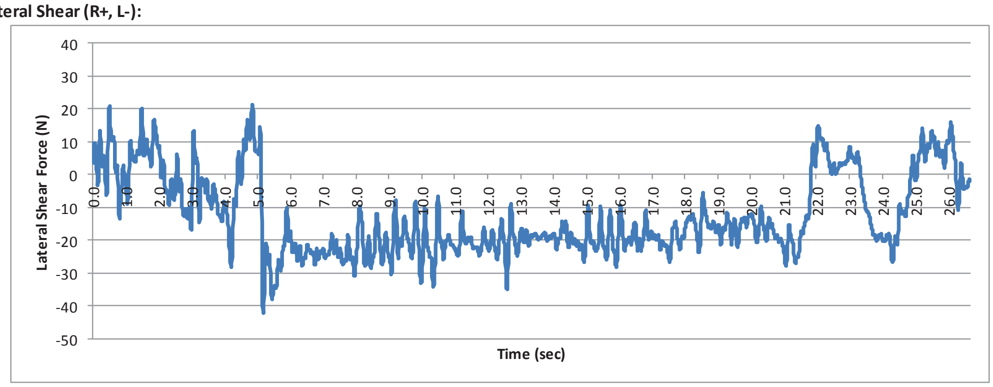
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



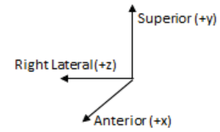
Lateral Shear (R+, L-):



CDU AMS Use - Night

Griffon MFTA - PDA: Postural Sequence

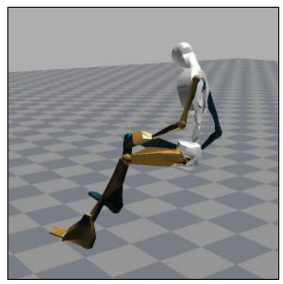
Postural Sequence:	CDU/AMS Use (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
The NFP programs in a new way-point into the CDU and relates these to other information for navigation like bearing and ground speed.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Arial Map - Hard Copy Flight Book

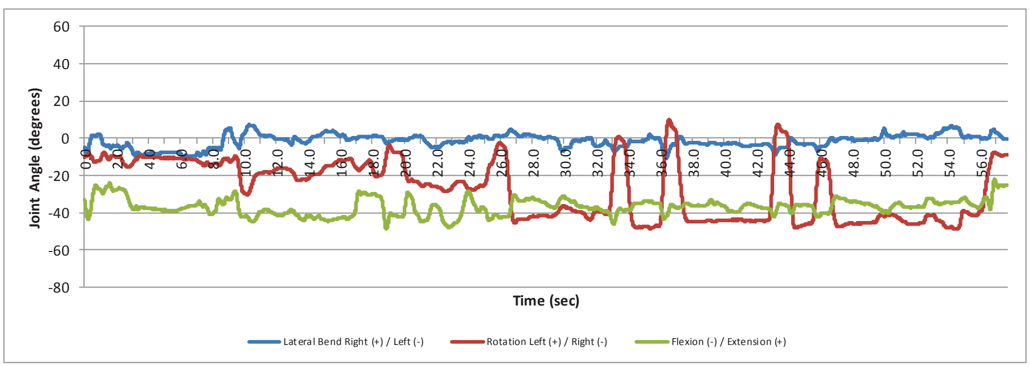
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



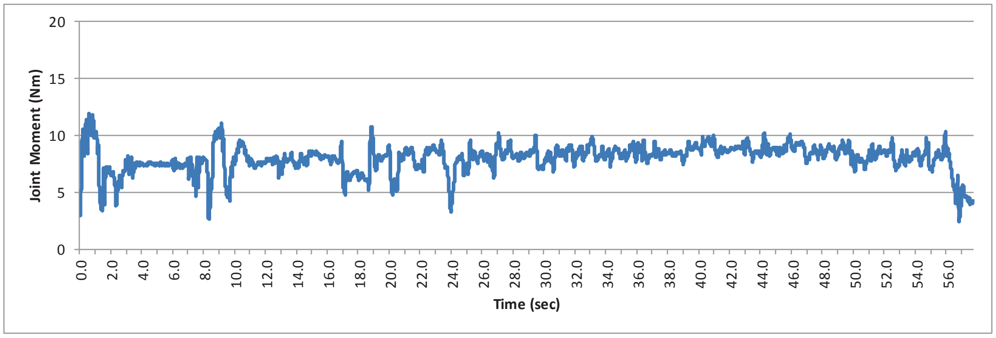
Posture Duration:	44.169	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

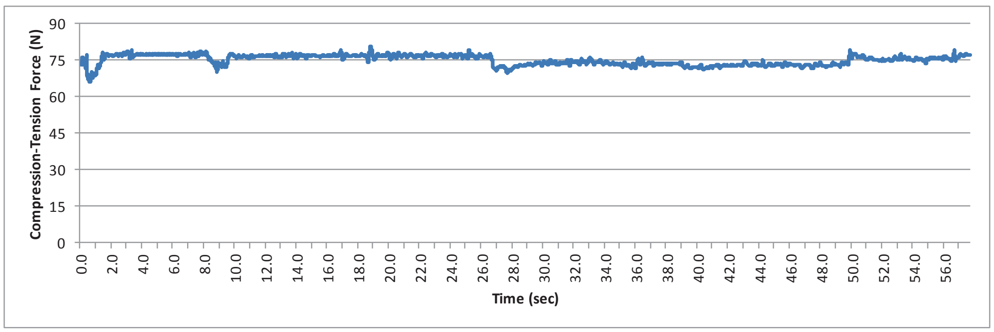
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	79.35	74.24	3279.71	Right Lateral Bend	11.91	2.02
Tension (N)	NA	NA	NA	Left Lateral Bend	-9.20	-3.62
Anterior Shear (N)	24.13	5.53	43.35	Left Axial Rotation	23.21	10.12
Posterior Shear (N)	-33.30	-12.91	-469.11	Right Axial Rotation	-35.42	-26.22
Right Lateral Shear (N)	23.27	4.94	29.19	Extension	NA	NA
Left Lateral Shear (N)	-31.34	-17.17	-656.99	Flexion	-39.37	-33.05
Torque (Resultant) (Nm)	4.50	7.31	138.44			
Right Lateral Moment (+Mx) (Nm	2.97	1.10	6.95			
Left Lateral Moment (-Mx) (Nm)	-5.21	-1.93	-73.03			
Left Axial Moment (+My) (Nm)	2.82	1.40	53.20			
Right Axial Moment (-My) (Nm)	-1.66	-0.40	-2.48			
Extension Moment (+Mz) (Nm)	8.82	6.78	299.68			
Flexion Moment (-Mz) (Nm)	NA	NA	NA			

CDU AMS Use - Night

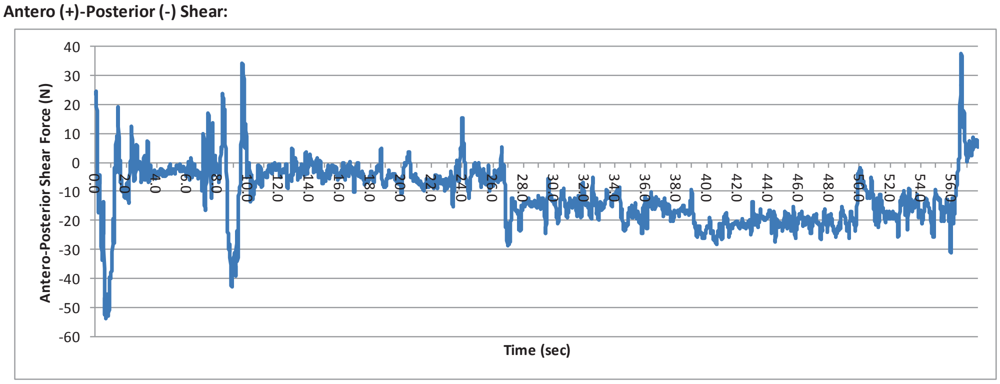
Resultant Neck Torque:



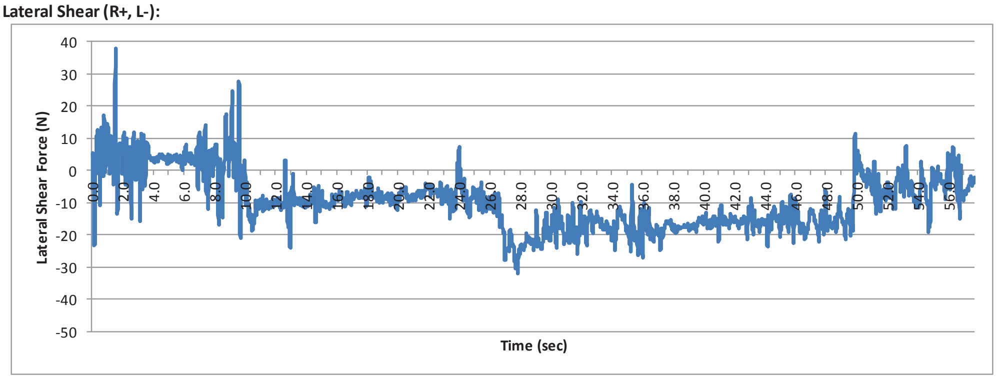
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



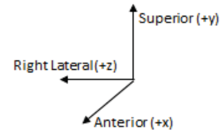
Lateral Shear (R+, L-):



Hard Turn NFP Side - Day

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Hard Turn NFP Side (NFP)
DAY	
Participant # (Sample Graphs):	NFP07
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



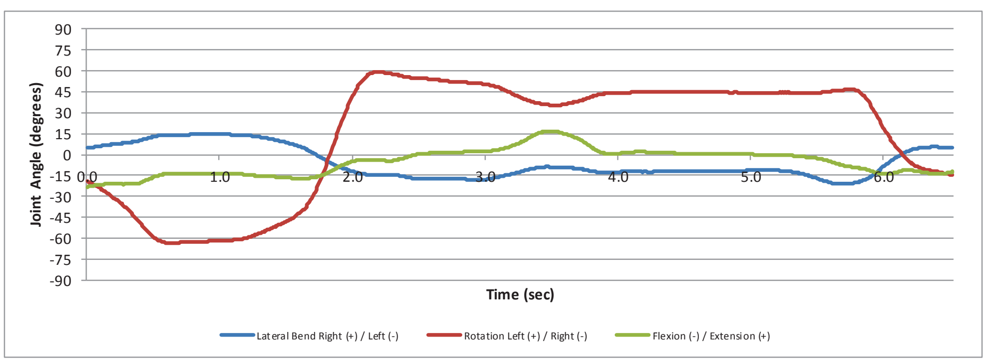
Task Description:	**Equipment Considerations:**
Banking to the NFP side, the NFP confirms area clear scanning to the left and top.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Day):



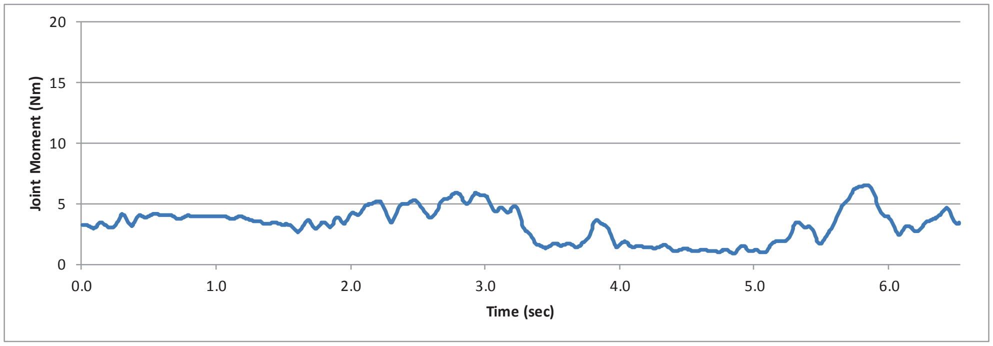
Posture Duration:	6.117	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

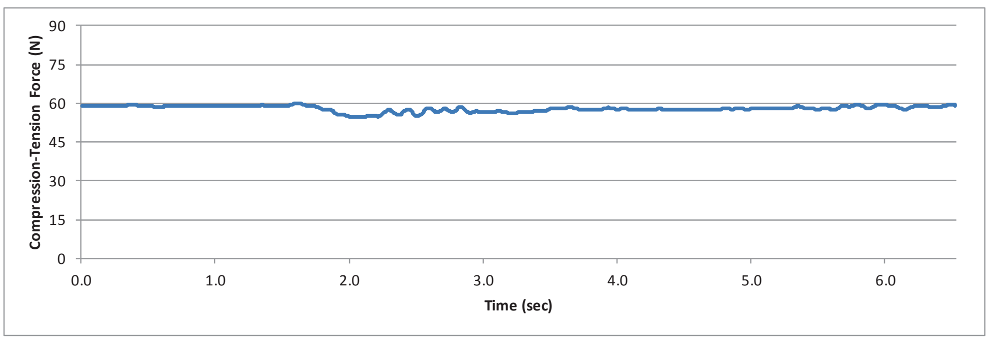
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	59.68	57.46	351.94	Right Lateral Bend	6.38	4.42
Tension (N)	NA	NA	NA	Left Lateral Bend	-14.16	-8.93
Anterior Shear (N)	12.88	4.94	14.43	Left Axial Rotation	54.70	51.66
Posterior Shear (N)	-21.28	-10.77	-34.49	Right Axial Rotation	-38.59	-32.73
Right Lateral Shear (N)	16.18	7.77	28.98	Extension	12.89	4.73
Left Lateral Shear (N)	-14.75	-12.23	-29.32	Flexion	-26.61	-17.75
Torque (Resultant) (Nm)	5.68	3.97	20.86			
Right Lateral Moment (+Mx) (Nm)	3.90	2.17	9.67			
Left Lateral Moment (-Mx) (Nm)	-3.26	-2.26	-5.68			
Left Axial Moment (+My) (Nm)	1.05	0.53	1.58			
Right Axial Moment (-My) (Nm)	-1.10	-0.44	-1.37			
Extension Moment (+Mz) (Nm)	5.35	3.09	16.15			
Flexion Moment (-Mz) (Nm)	-1.23	-0.70	-1.26			

Hard Turn NFP Side – Day

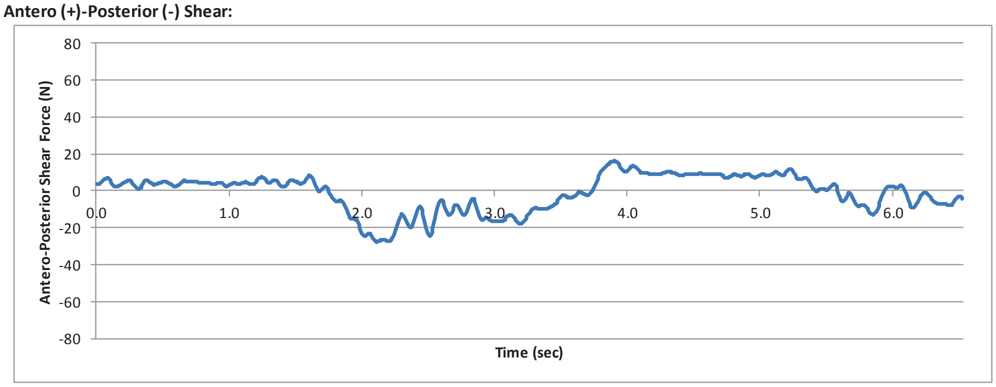
Resultant Neck Torque:



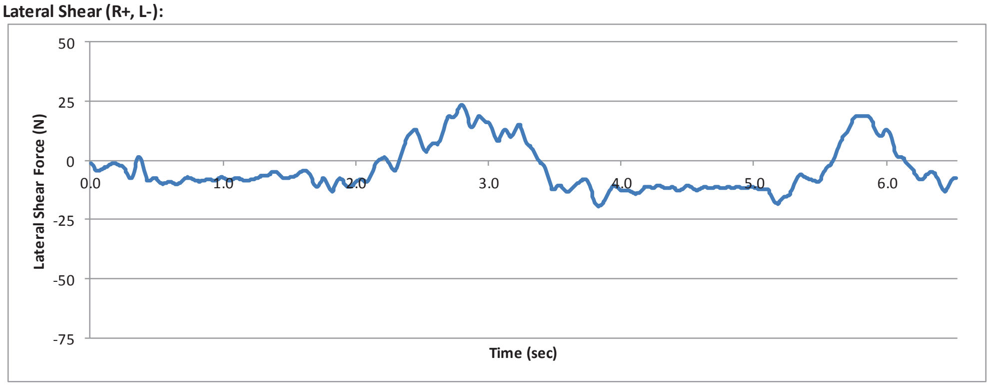
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



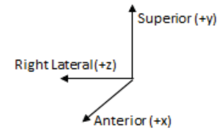
Lateral Shear (R+, L-):



Hard Turn NFP Side – Night

Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Hard Turn NFP Side (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP07
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



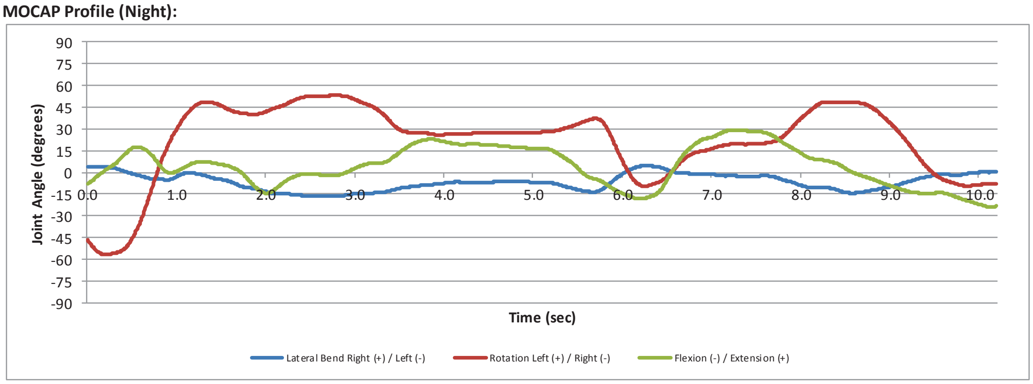
Task Description:	**Equipment Considerations:**
Banking to the NFP side, the NFP confirms area clear scanning to the left and top.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

Photograph

MOCAP Screen Capture

MOCAP Profile (Night):



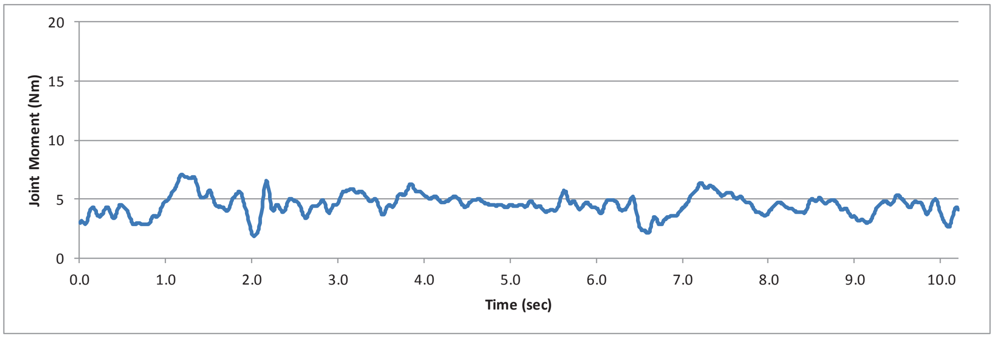
Posture Duration:	11.990	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

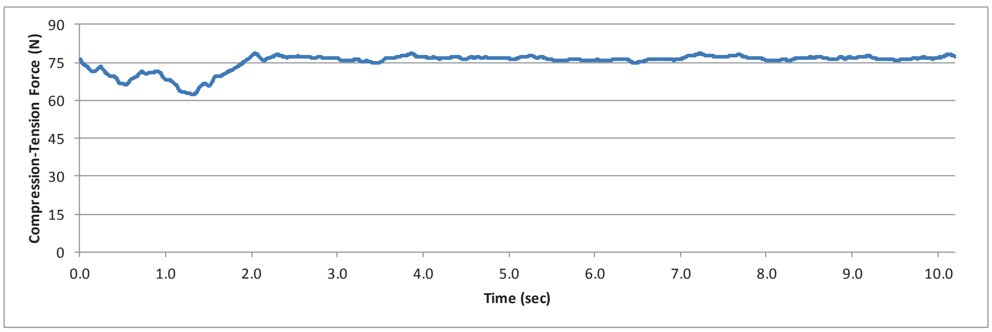
Force	Peak	Mean	Area	ROM	Peak (degrees)	Mean (degrees)
Compression (N)	78.80	73.99	887.68	Right Lateral Bend	5.03	2.51
Tension (N)	NA	NA	NA	Left Lateral Bend	-19.48	-13.26
Anterior Shear (N)	32.00	10.63	41.78	Left Axial Rotation	60.27	51.42
Posterior Shear (N)	-43.74	-14.37	-115.95	Right Axial Rotation	-29.43	-16.33
Right Lateral Shear (N)	14.41	9.24	29.55	Extension	9.90	3.56
Left Lateral Shear (N)	-39.26	-14.84	-130.57	Flexion	-22.19	-8.64
Torque (Resultant) (Nm)	4.96	4.54	31.13			
Right Lateral Moment (+Mx) (Nm	5.04	2.62	21.82			
Left Lateral Moment (-Mx) (Nm)	-4.24	-2.51	-9.20			
Left Axial Moment (+My) (Nm)	2.23	0.71	6.01			
Right Axial Moment (-My) (Nm)	-1.40	-0.51	-1.81			
Extension Moment (+Mz) (Nm)	7.36	3.27	29.57			
Flexion Moment (-Mz) (Nm)	-3.87	-2.06	-6.07			

Hard Turn NFP Side - Night

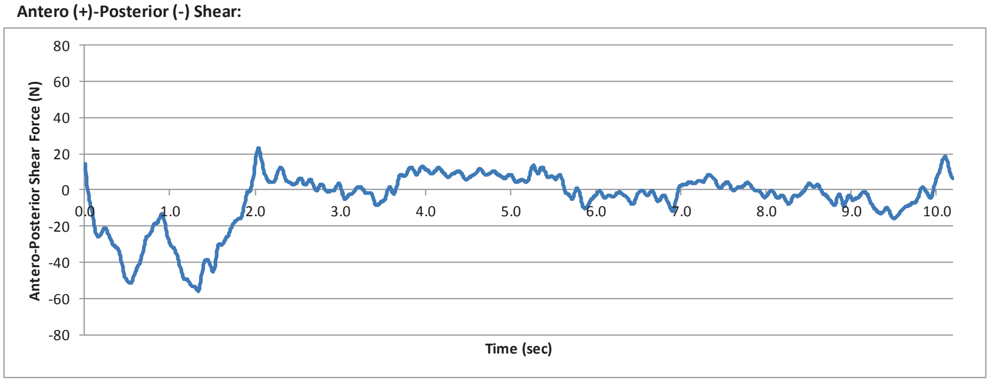
Resultant Neck Torque:



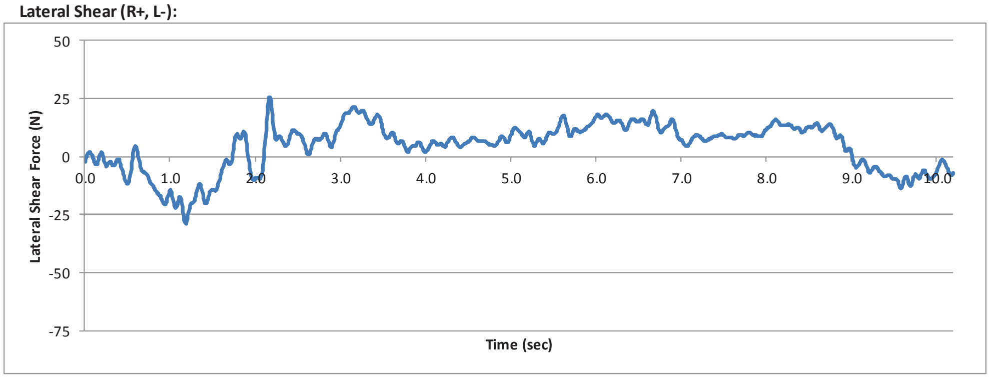
Compression(+)-Tension(-):



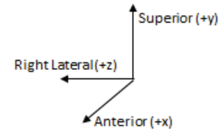
Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):



Inside Scan Ceiling Switches - Day



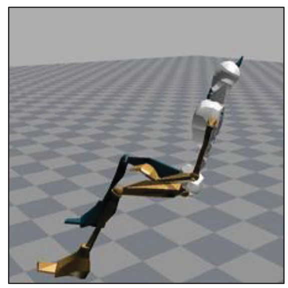
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Inside Scan Ceiling Switches (NFP)
DAY	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only

Task Description:	Equipment Considerations:
Pilot views settings on ceiling switches and dials, in addition to sense of touch for setting positions.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

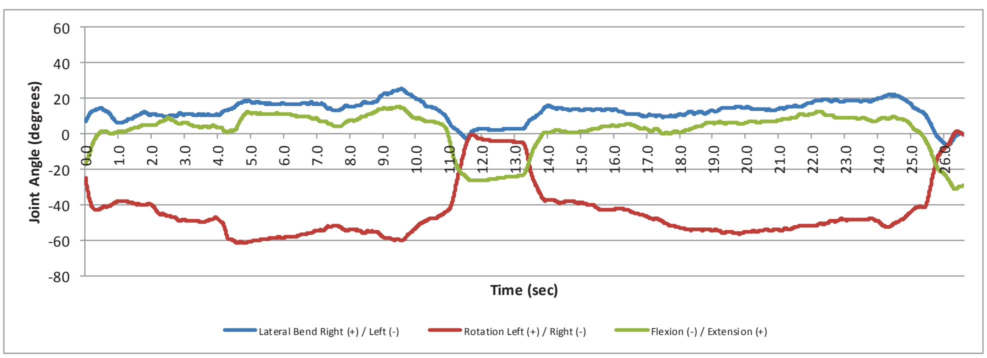
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	11.556	seconds

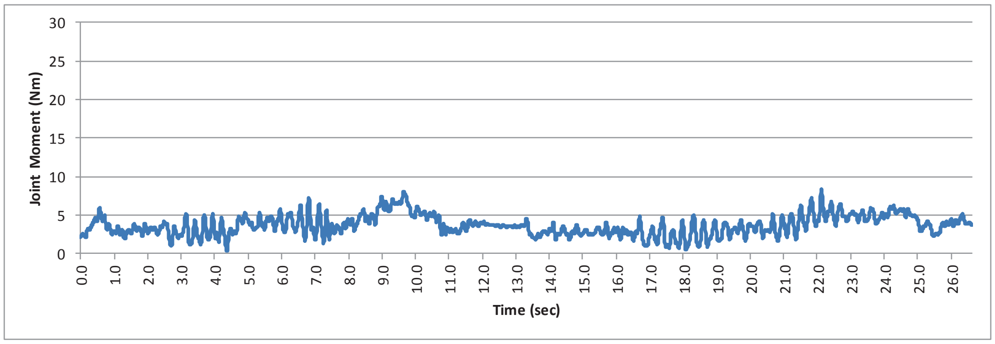
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	59.99	58.33	674.55
Tension (N)	NA	NA	NA
Anterior Shear (N)	23.35	6.52	63.21
Posterior Shear (N)	-12.79	-4.09	-9.15
Right Lateral Shear (N)	13.57	4.36	14.40
Left Lateral Shear (N)	-24.95	-8.98	-74.18
Torque (Resultant) (Nm)	5.22	3.14	31.14
Right Lateral Moment (+Mx) (Nm)	2.19	0.90	3.56
Left Lateral Moment (-Mx) (Nm)	-4.48	-2.57	-19.53
Left Axial Moment (+My) (Nm)	0.85	0.26	1.63
Right Axial Moment (-My) (Nm)	-1.03	-0.33	-1.76
Extension Moment (+Mz) (Nm)	4.22	1.96	10.47
Flexion Moment (-Mz) (Nm)	-3.64	-1.58	-11.79

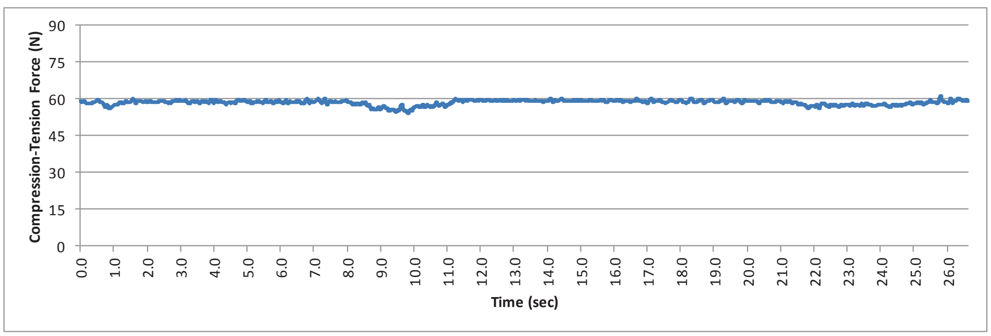
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	16.73	13.50
Left Lateral Bend	-11.36	-7.51
Left Axial Rotation	10.76	6.43
Right Axial Rotation	-49.11	-37.09
Extension	21.29	8.63
Flexion	-26.44	-14.81

Inside Scan Ceiling Switches - Day

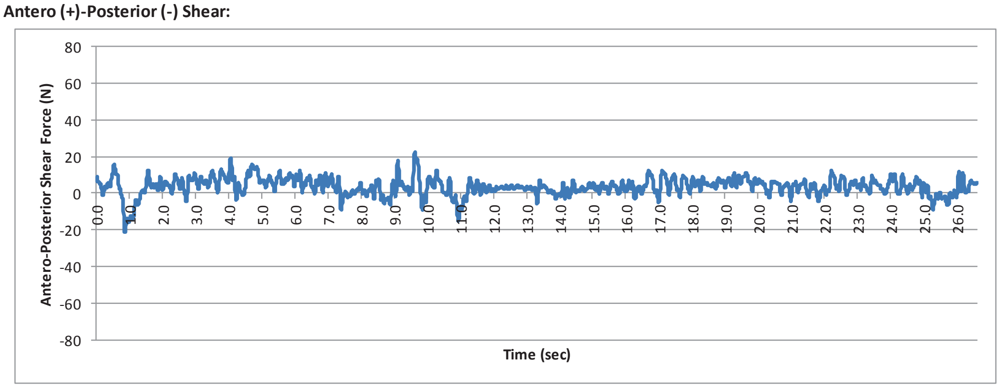
Resultant Neck Torque:



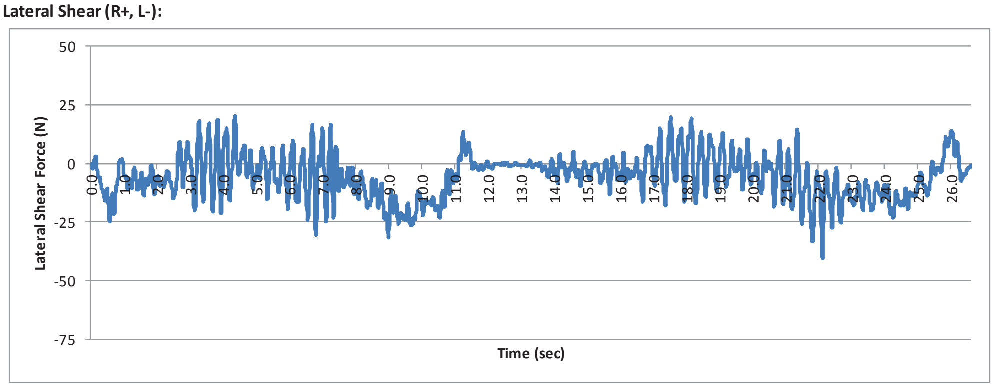
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



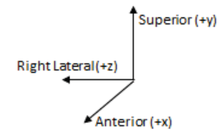
Lateral Shear (R+, L-):



Inside Scan Ceiling Switches - Night

Griffon MFTA - PDA: Postural Sequence

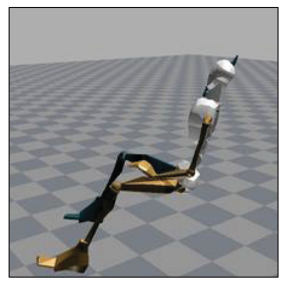
Postural Sequence:	Inside Scan Ceiling Switches (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
Pilot views settings on ceiling switches and dials, in addition to sense of touch for setting positions.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

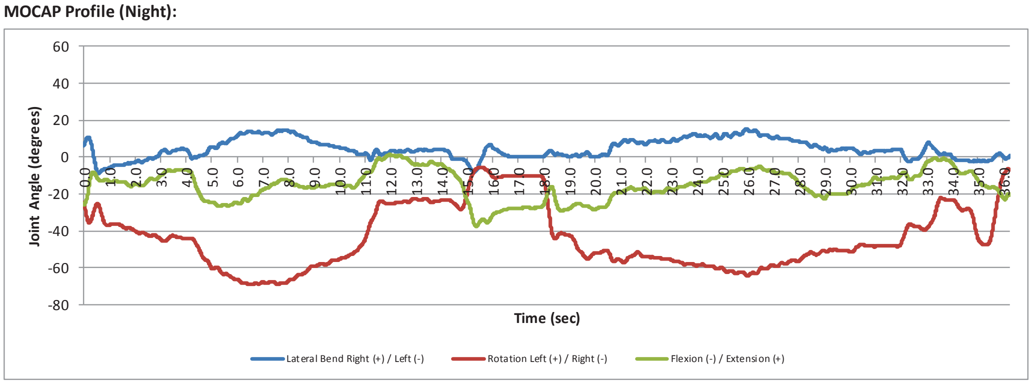
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	14.925	seconds

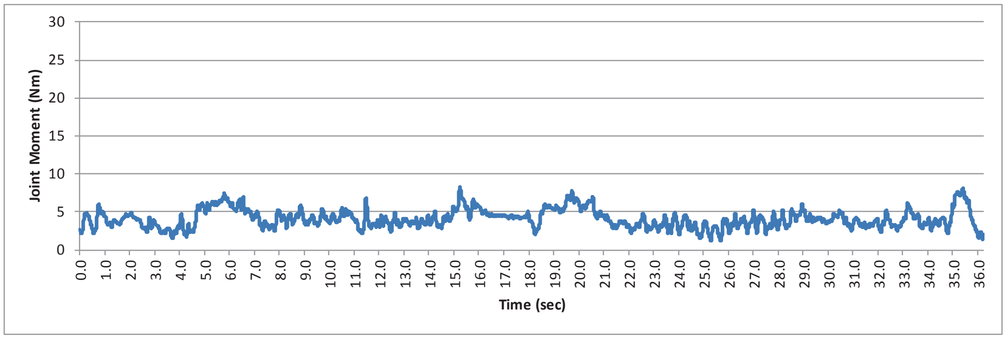
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	80.12	75.48	1127.10
Tension (N)	NA	NA	NA
Anterior Shear (N)	30.03	9.04	77.40
Posterior Shear (N)	-27.05	-9.40	-59.90
Right Lateral Shear (N)	16.73	8.46	57.85
Left Lateral Shear (N)	-33.54	-12.74	-103.05
Torque (Resultant) (Nm)	9.37	4.80	51.21
Right Lateral Moment (+Mx) (Nm	4.90	2.98	25.63
Left Lateral Moment (-Mx) (Nm)	-5.11	-2.63	-26.46
Left Axial Moment (+My) (Nm)	1.22	0.33	2.27
Right Axial Moment (-My) (Nm)	-1.71	-0.52	-4.10
Extension Moment (+Mz) (Nm)	6.75	3.35	38.72
Flexion Moment (-Mz) (Nm)	-4.97	-1.64	-5.52

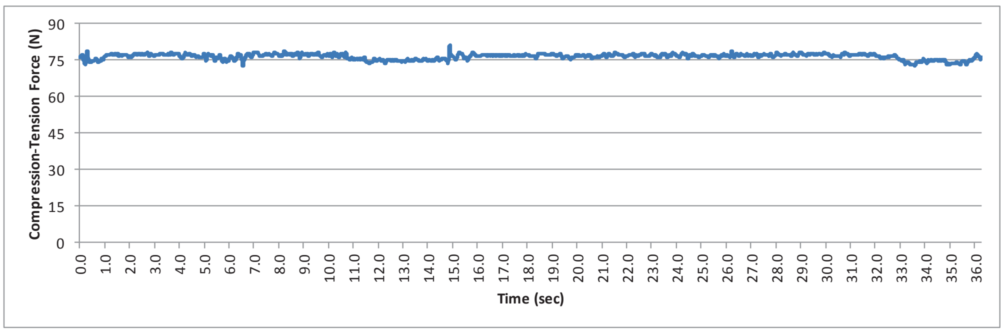
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	23.85	8.70
Left Lateral Bend	-22.45	-15.51
Left Axial Rotation	9.65	4.67
Right Axial Rotation	-42.95	-33.07
Extension	12.19	6.66
Flexion	-30.59	-16.42

Inside Scan Ceiling Switches - Night

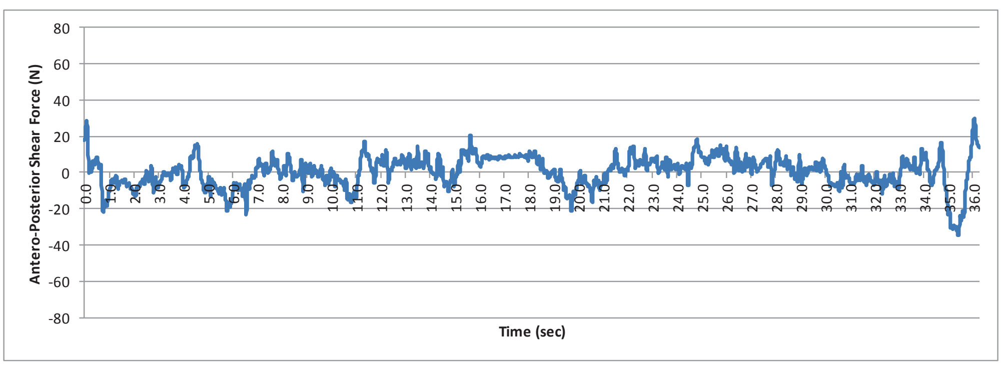
Resultant Neck Torque:



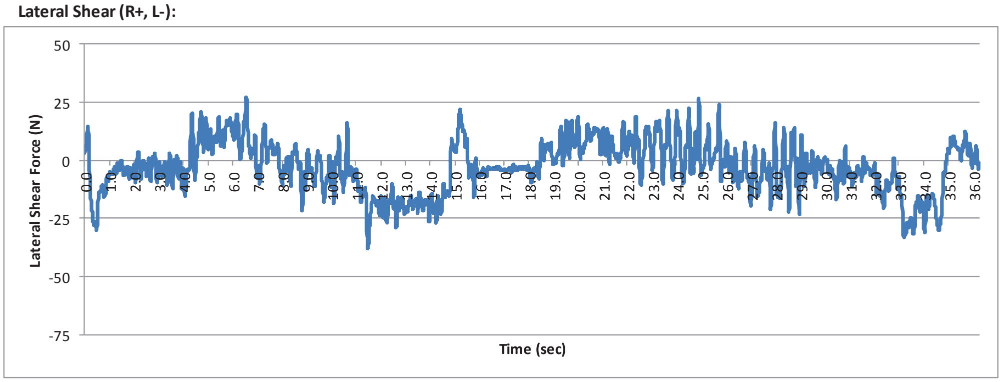
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



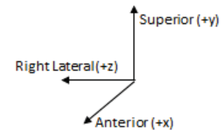
Lateral Shear (R+, L-):



Inside Scan Dash Gauges - Day

Griffon MFTA - PDA: Postural Sequence

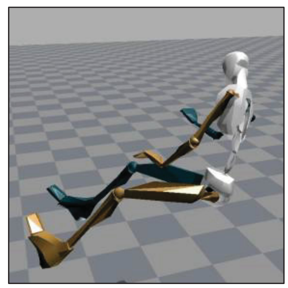
Postural Sequence:	Inside Scan Dash Gauges (NFP)
DAY	
Participant # (Sample Graphs):	NFP05
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	**Equipment Considerations:**
NFP scans dash gauges, warning lights, and switches from the center of the dash to their side of the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

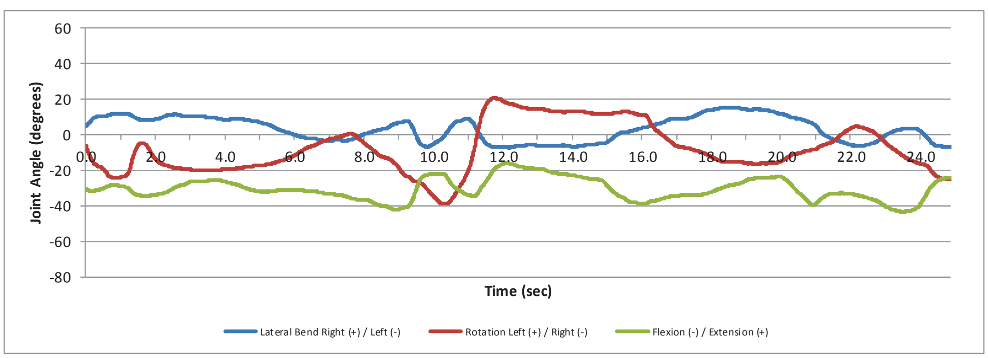
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	12.438	seconds

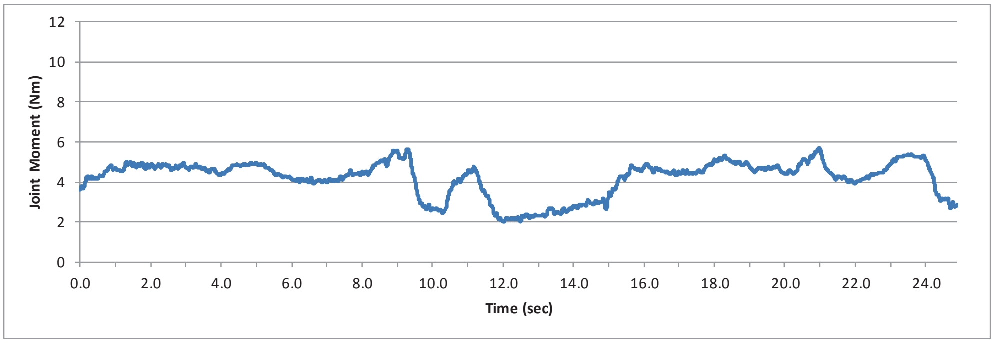
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	60.32	57.31	713.27
Tension (N)	NA	NA	NA
Anterior Shear (N)	12.62	6.62	45.56
Posterior Shear (N)	-11.16	-5.12	-34.21
Right Lateral Shear (N)	6.31	2.84	2.62
Left Lateral Shear (N)	-24.80	-11.79	-135.81
Torque (Resultant) (Nm)	5.87	5.14	54.79
Right Lateral Moment (+Mx) (Nm)	1.29	0.61	1.38
Left Lateral Moment (-Mx) (Nm)	-5.35	-3.04	-30.94
Left Axial Moment (+My) (Nm)	1.65	0.79	8.70
Right Axial Moment (-My) (Nm)	-0.59	-0.26	-0.35
Extension Moment (+Mz) (Nm)	5.84	3.93	47.96
Flexion Moment (-Mz) (Nm)	-0.63	-0.20	-0.30

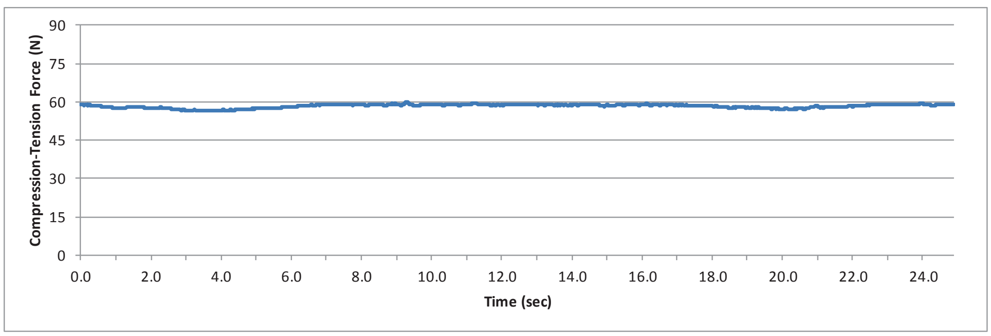
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	20.50	11.76
Left Lateral Bend	-7.06	-4.10
Left Axial Rotation	11.04	9.98
Right Axial Rotation	-40.22	-23.46
Extension	NA	NA
Flexion	-40.95	-28.12

Inside Scan Dash Gauges - Day

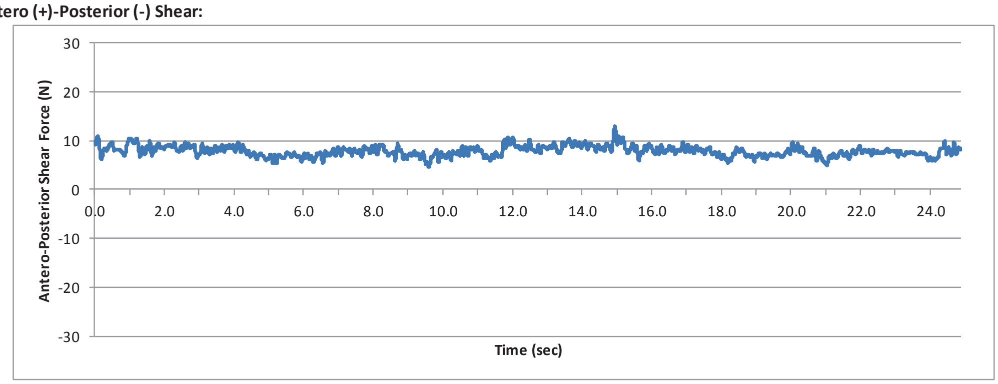
Resultant Neck Torque:



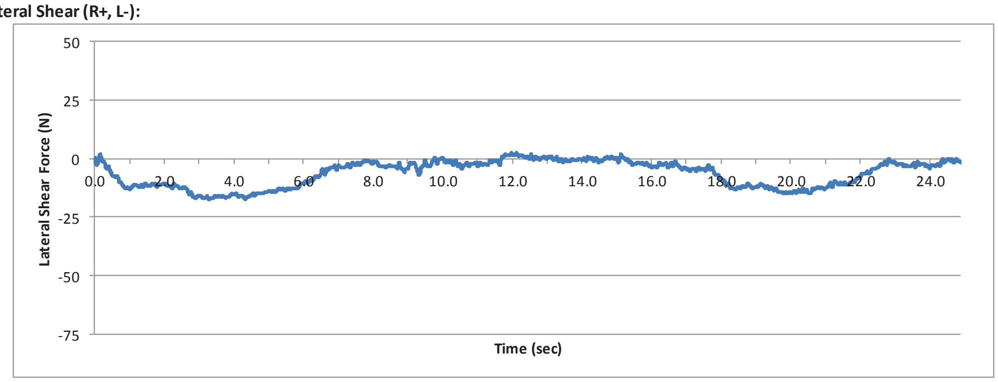
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



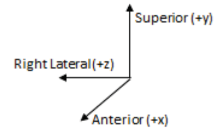
Lateral Shear (R+, L-):



Inside Scan Dash Gauges - Night

Griffon MFTA - PDA: Postural Sequence

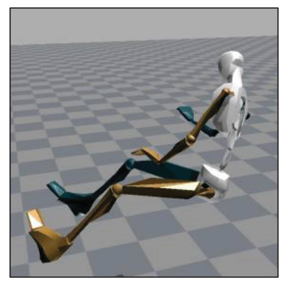
Postural Sequence:	Inside Scan Dash Gauges (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP05
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
NFP scans dash gauges, warning lights, and switches from the center of the dash to their side of the AC.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

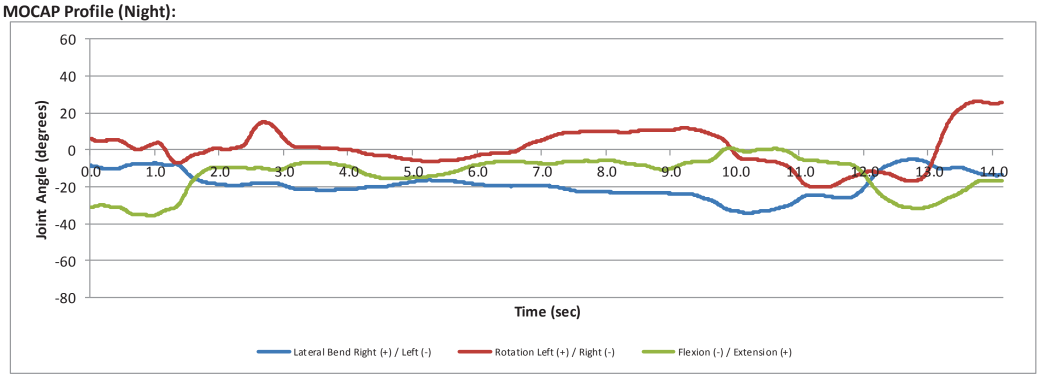
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	11.753	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	77.88	74.52	876.52
Tension (N)	NA	NA	NA
Anterior Shear (N)	16.68	6.50	33.82
Posterior Shear (N)	-16.25	-7.58	-49.68
Right Lateral Shear (N)	8.88	4.18	5.09
Left Lateral Shear (N)	-32.94	-17.60	-185.53
Torque (Resultant) (Nm)	5.91	4.64	39.01
Right Lateral Moment (+Mx) (Nm	2.78	1.55	7.75
Left Lateral Moment (-Mx) (Nm)	-5.44	-3.56	-24.09
Left Axial Moment (+My) (Nm)	1.71	0.51	4.13
Right Axial Moment (-My) (Nm)	-1.15	-0.32	-1.15
Extension Moment (+Mz) (Nm)	7.35	3.09	33.01
Flexion Moment (-Mz) (Nm)	-1.58	-0.48	-0.51

ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	16.42	11.79
Left Lateral Bend	-17.18	-10.44
Left Axial Rotation	18.22	11.35
Right Axial Rotation	-38.25	-24.01
Extension	5.64	4.61
Flexion	-32.99	-17.66

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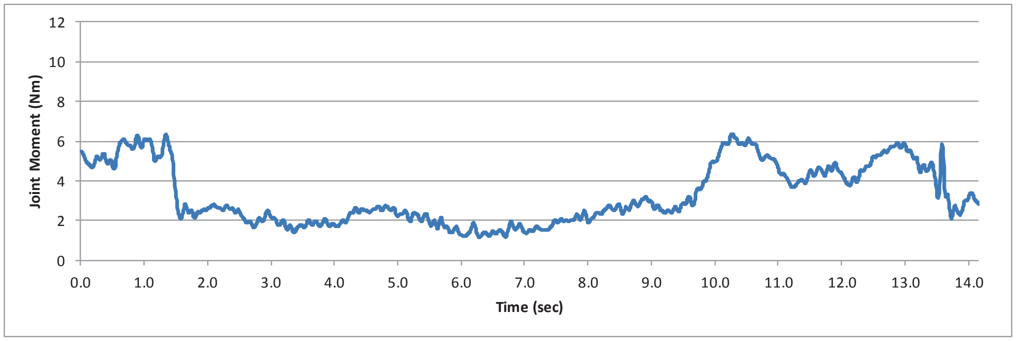
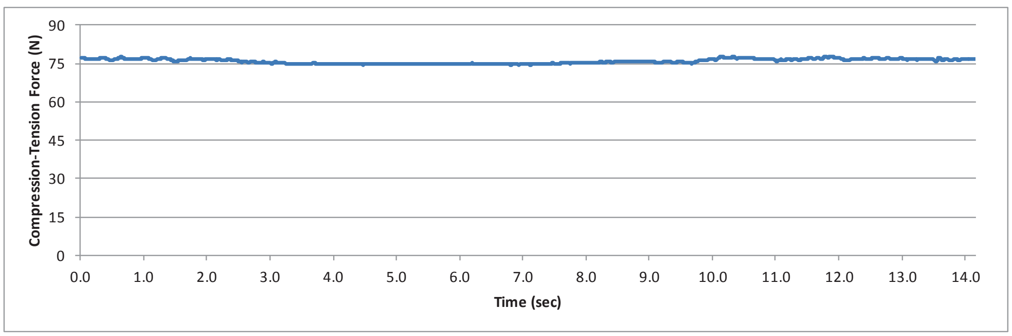
Inside Scan Dash Gauges - Night

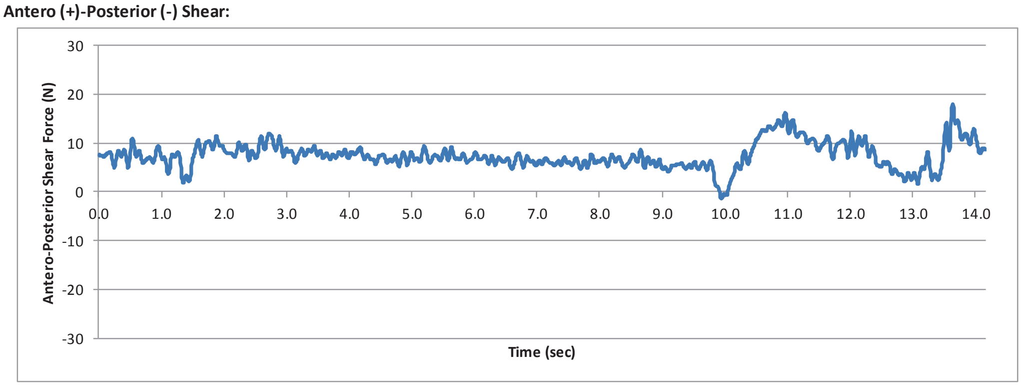
Resultant Neck Torque:



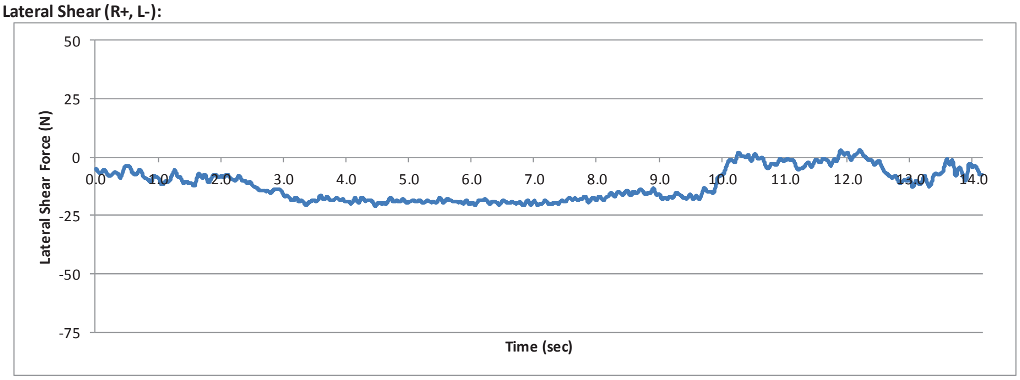
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



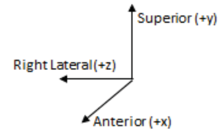
Lateral Shear (R+, L-):



Map Doc Referencing - Day

Griffon MFTA - PDA: Postural Sequence

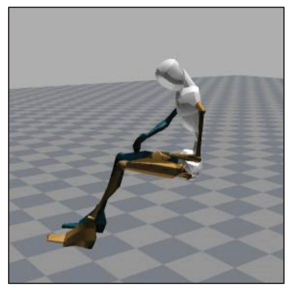
Postural Sequence:	Map/Doc Referencing (NFP)
DAY	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
Pilot views hand-held maps and mission package docs, and toggles the next waypoint on CDU.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Arial Map - Hard Copy Flight Book

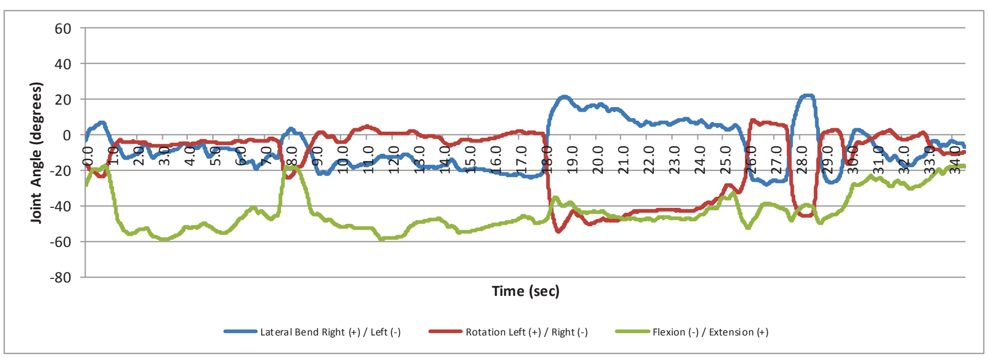
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	18.683	seconds

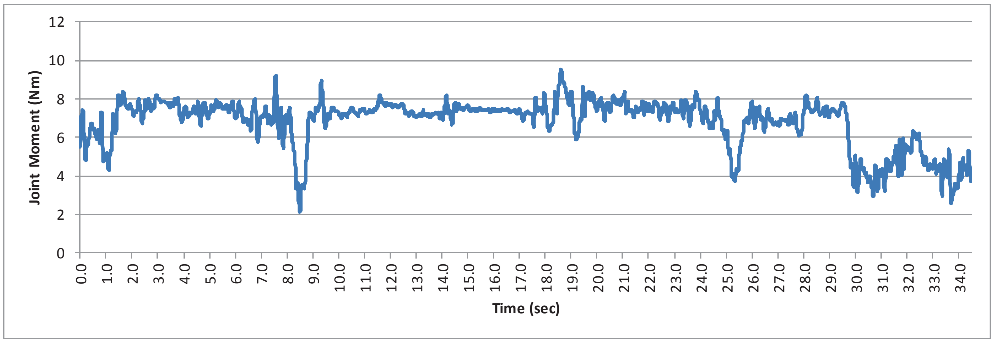
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	60.83	57.64	1077.47
Tension (N)	NA	NA	NA
Anterior Shear (N)	15.15	4.44	29.09
Posterior Shear (N)	-23.93	-7.66	-92.95
Right Lateral Shear (N)	13.85	5.17	28.89
Left Lateral Shear (N)	-28.05	-11.89	-155.84
Torque (Resultant) (Nm)	5.81	6.29	84.03
Right Lateral Moment (+Mx) (Nm)	2.66	2.00	14.96
Left Lateral Moment (-Mx) (Nm)	-5.47	-2.32	-29.56
Left Axial Moment (+My) (Nm)	2.27	1.03	13.13
Right Axial Moment (-My) (Nm)	-1.58	-0.42	-2.48
Extension Moment (+Mz) (Nm)	7.17	5.58	104.23
Flexion Moment (-Mz) (Nm)	NA	NA	NA

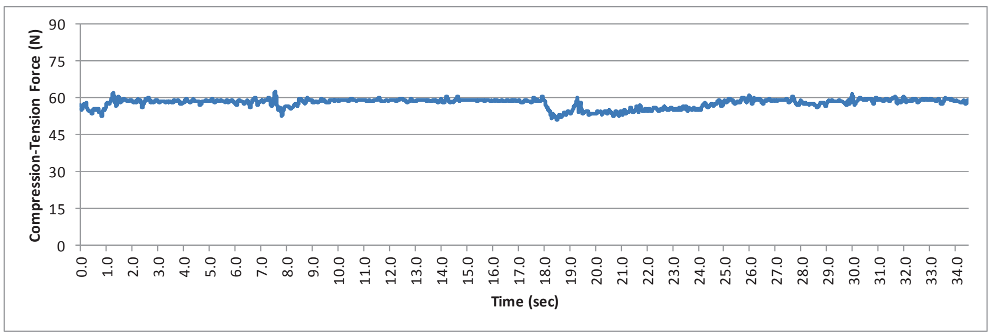
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	20.87	10.27
Left Lateral Bend	-12.70	-10.53
Left Axial Rotation	23.07	13.00
Right Axial Rotation	-39.79	-22.46
Extension	NA	NA
Flexion	-47.53	-40.06

Map Doc Referencing - Day

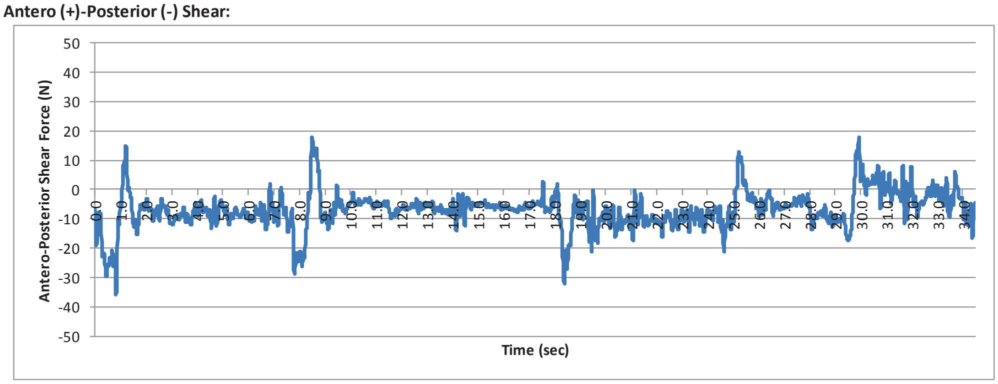
Resultant Neck Torque:



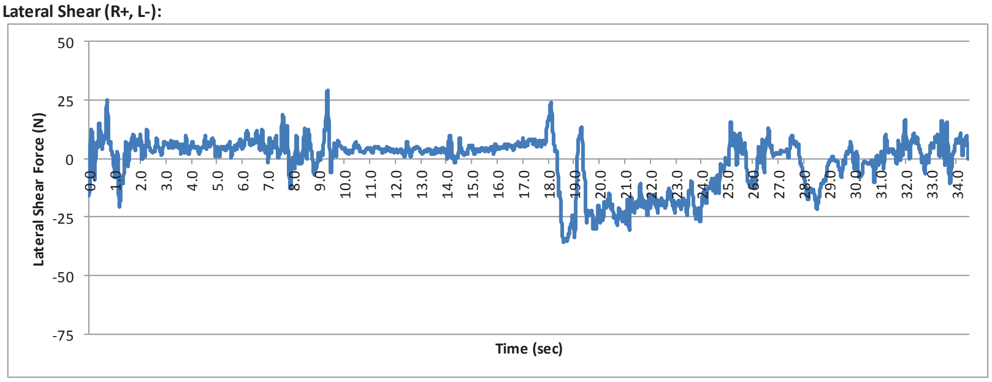
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



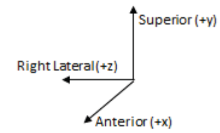
Lateral Shear (R+, L-):



Map Doc Referencing - Night

Griffon MFTA - PDA: Postural Sequence

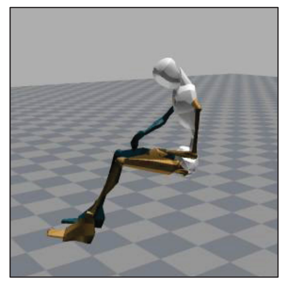
Postural Sequence:	Map/Doc Referencing (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Pilot views hand-held maps and mission package docs, and toggles the next waypoint on CDU.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV) Arial Map - Hard Copy Flight Book

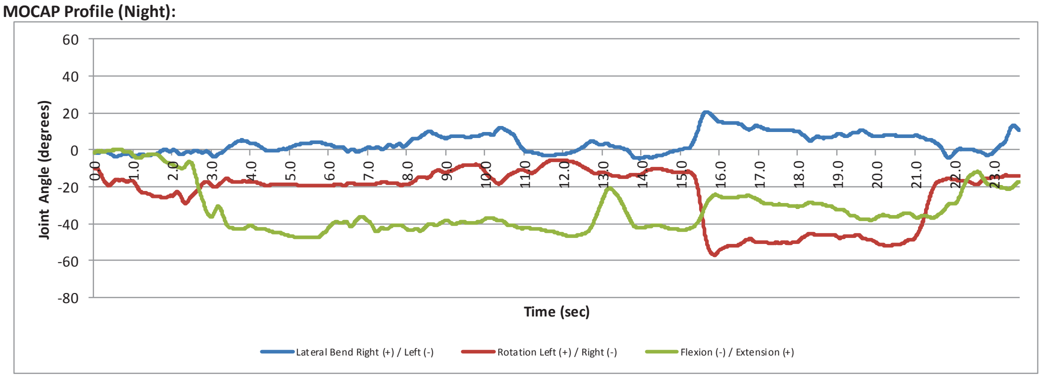
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	25.692	seconds

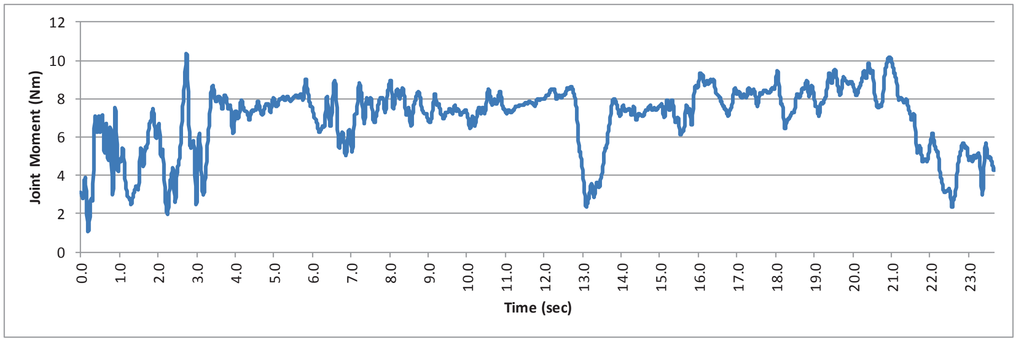
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	79.44	75.56	1941.90
Tension (N)	NA	NA	NA
Anterior Shear (N)	31.11	4.97	36.56
Posterior Shear (N)	-36.70	-11.47	-210.26
Right Lateral Shear (N)	19.63	6.20	26.89
Left Lateral Shear (N)	-29.90	-11.45	-244.68
Torque (Resultant) (Nm)	2.81	6.37	46.76
Right Lateral Moment (+Mx) (Nm	3.32	0.82	5.52
Left Lateral Moment (-Mx) (Nm)	-5.15	-1.99	-37.69
Left Axial Moment (+My) (Nm)	1.93	0.71	15.24
Right Axial Moment (-My) (Nm)	-1.25	-0.36	-1.50
Extension Moment (+Mz) (Nm)	9.10	5.92	151.43
Flexion Moment (-Mz) (Nm)	-3.34	-2.00	-0.48

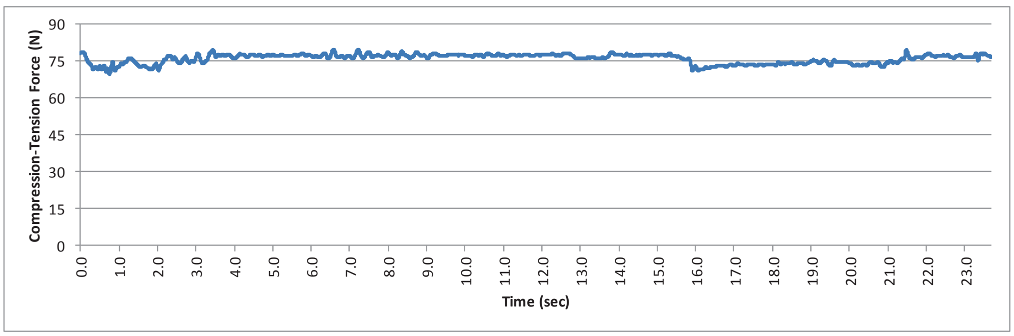
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	12.01	4.25
Left Lateral Bend	-6.22	-2.73
Left Axial Rotation	24.46	14.83
Right Axial Rotation	-29.58	-17.29
Extension	0.16	0.10
Flexion	-38.66	-27.49

Map Doc Referencing - Night

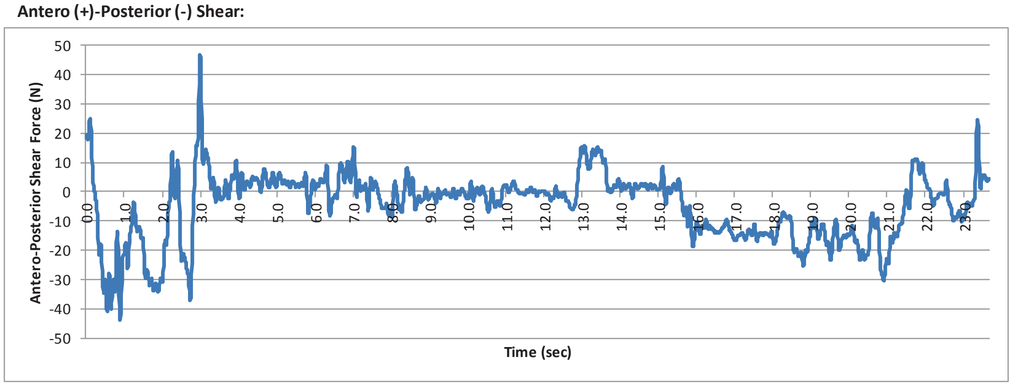
Resultant Neck Torque:



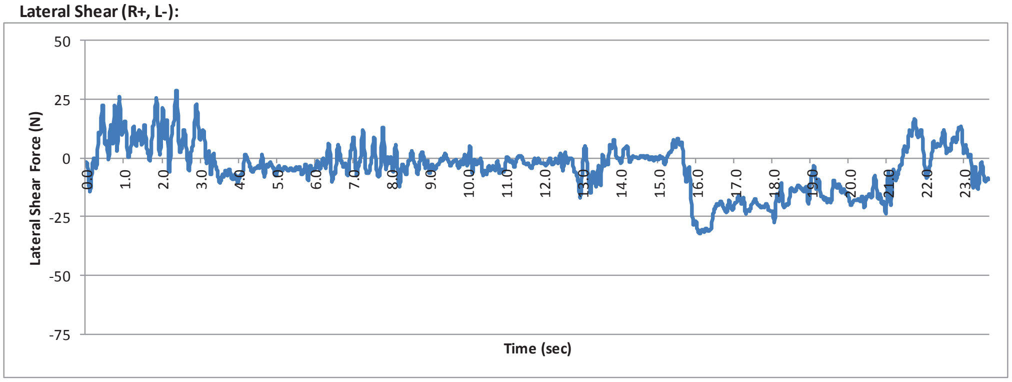
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



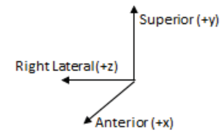
Lateral Shear (R+, L-):



MX15 Use - Day

Griffon MFTA - PDA: Postural Sequence

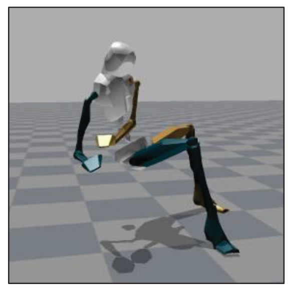
Postural Sequence:	MX-15 Use (NFP)
DAY	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
MX-15 Use – MMD Programming NFP programs in the location for the MX-15	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

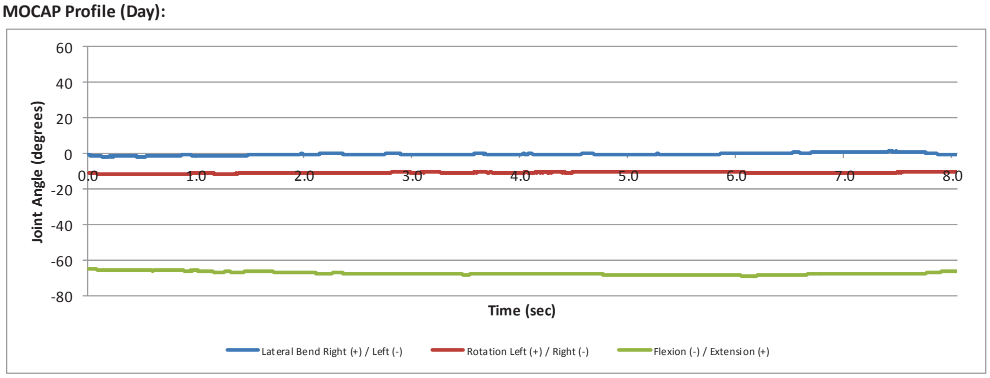
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	8.042	seconds

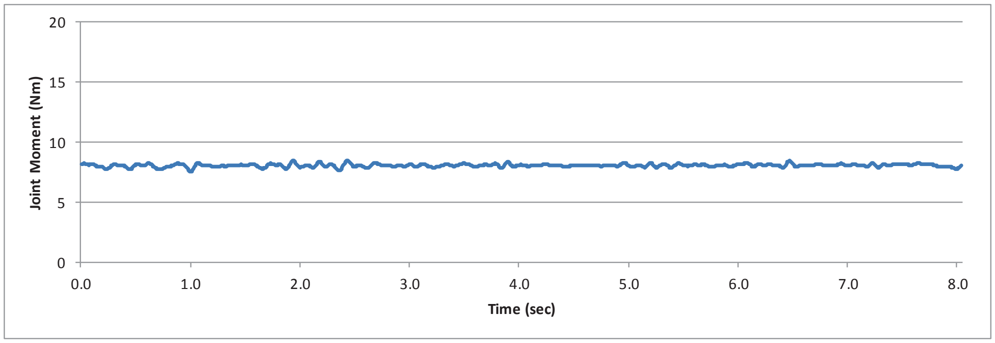
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	55.18	52.51	422.73
Tension (N)	NA	NA	NA
Anterior Shear (N)	NA	NA	NA
Posterior Shear (N)	-8.68	-6.15	-49.49
Right Lateral Shear (N)	NA	NA	NA
Left Lateral Shear (N)	-29.81	-27.17	-218.73
Torque (Resultant) (Nm)	1.21	8.06	9.27
Right Lateral Moment (+Mx) (Nm)	NA	NA	NA
Left Lateral Moment (-Mx) (Nm)	-1.49	-1.23	-9.93
Left Axial Moment (+My) (Nm)	3.92	3.53	28.40
Right Axial Moment (-My) (Nm)	NA	NA	NA
Extension Moment (+Mz) (Nm)	7.56	7.10	57.14
Flexion Moment (-Mz) (Nm)	NA	NA	NA

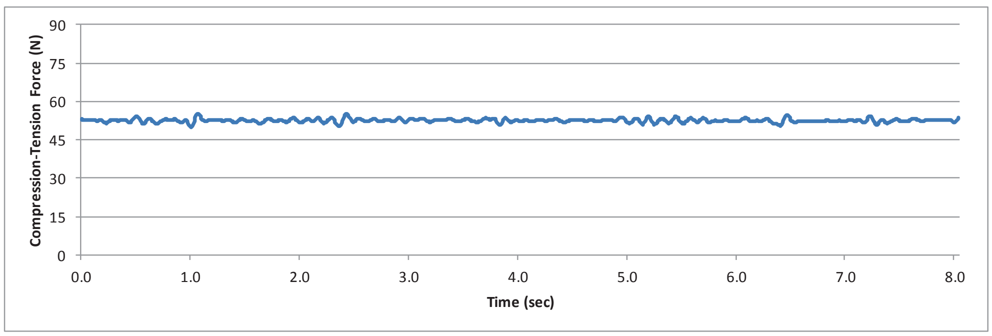
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	1.14	0.58
Left Lateral Bend	-1.78	-0.66
Left Axial Rotation	NA	NA
Right Axial Rotation	-11.67	-10.85
Extension	NA	NA
Flexion	-68.84	-67.45

MX15 Use - Day

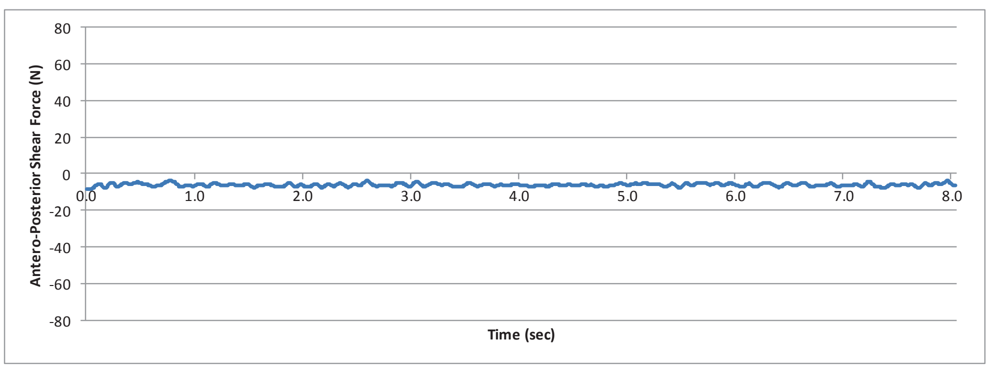
Resultant Neck Torque:



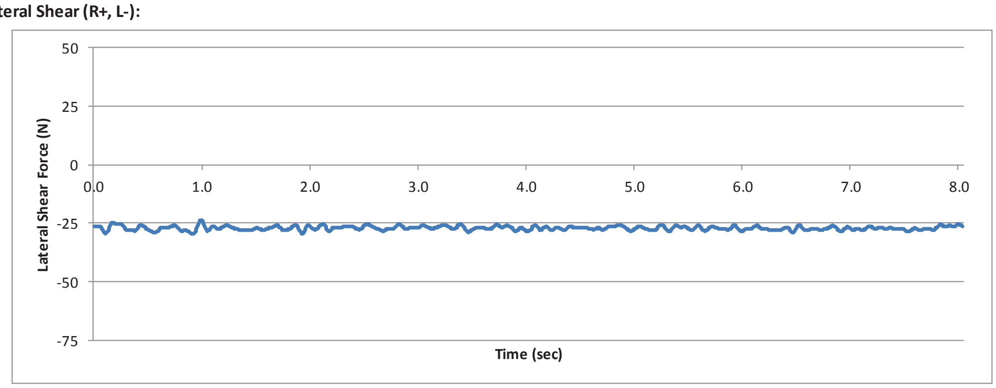
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):



MX15 Use - Night

Griffon MFTA - PDA: Postural Sequence

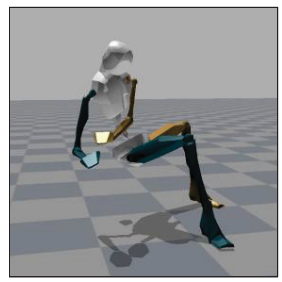
Postural Sequence:	MX-15 Use (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG

Superior (+y)
Right Lateral (+z)
Anterior (+x)

Task Description:	Equipment Considerations:
MX-15 Use – MMD Programming	Helmet (HGY 56/P or SPH-5)
NFP programs in the location for the MX-15	Flight Suit
	Life Preserver and Safety Vest (LPSV)

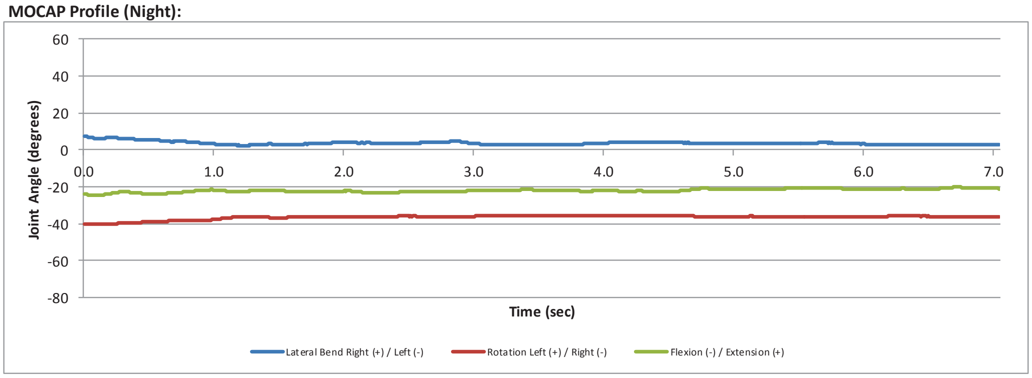
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	7.050	seconds

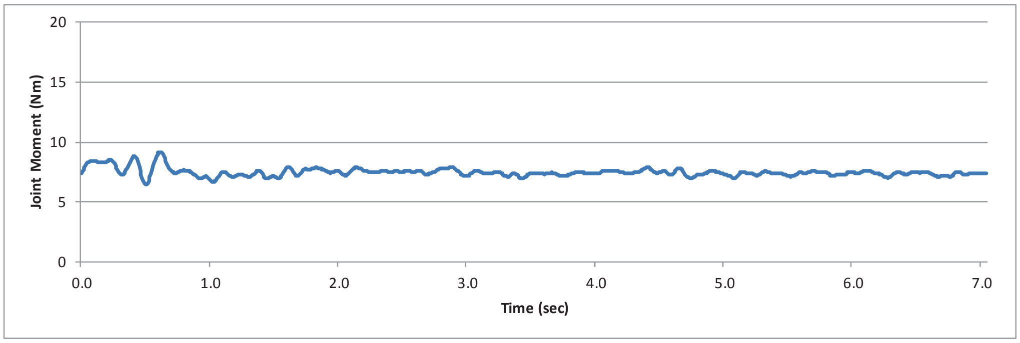
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	69.09	67.59	477.08
Tension (N)	NA	NA	NA
Anterior Shear (N)	3.91	2.50	0.12
Posterior Shear (N)	-15.92	-6.43	-45.04
Right Lateral Shear (N)	NA	NA	NA
Left Lateral Shear (N)	-43.59	-37.37	-263.75
Torque (Resultant) (Nm)	1.31	7.48	7.54
Right Lateral Moment (+Mx) (Nm	NA	NA	NA
Left Lateral Moment (-Mx) (Nm)	-6.74	-5.50	-38.80
Left Axial Moment (+My) (Nm)	2.61	2.01	14.19
Right Axial Moment (-My) (Nm)	NA	NA	NA
Extension Moment (+Mz) (Nm)	6.30	4.57	32.26
Flexion Moment (-Mz) (Nm)	NA	NA	NA

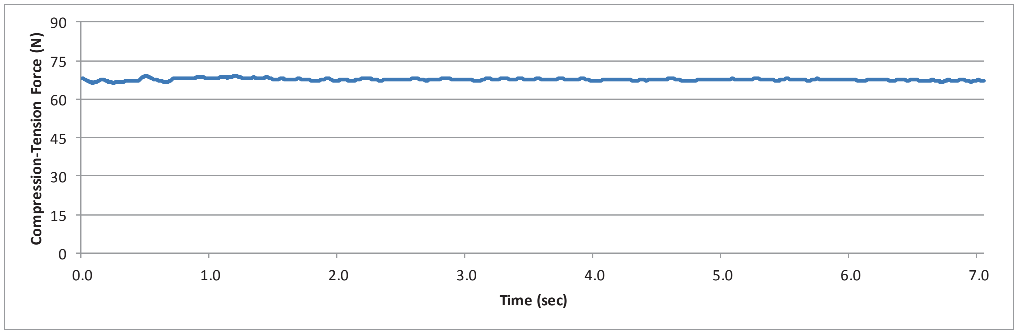
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	7.24	3.59
Left Lateral Bend	NA	NA
Left Axial Rotation	NA	NA
Right Axial Rotation	-40.49	-36.59
Extension	NA	NA
Flexion	-24.47	-22.06

MX15 Use - Night

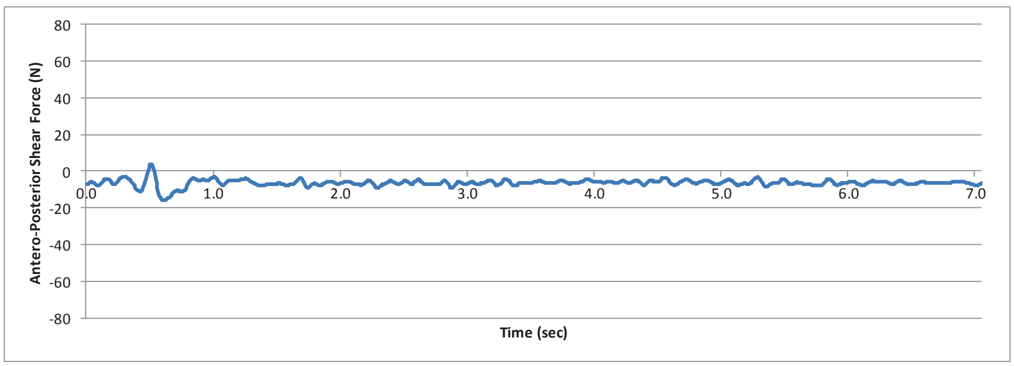
Resultant Neck Torque:



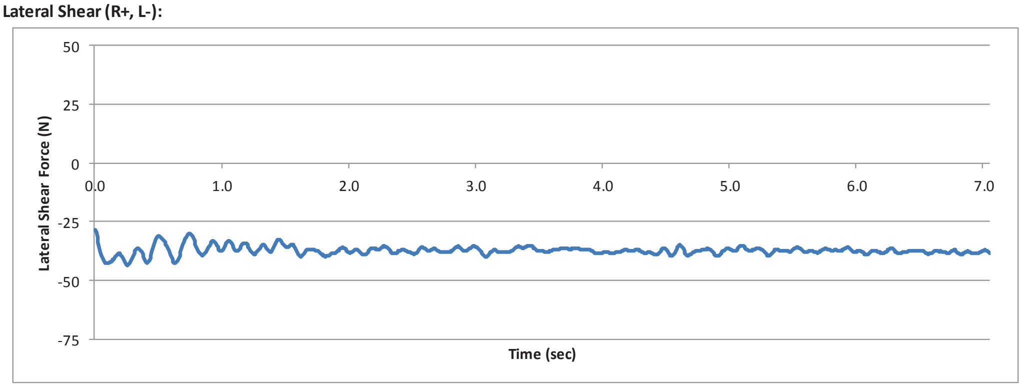
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



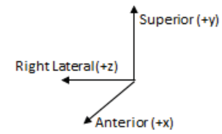
Lateral Shear (R+, L-):



Outside Scan Confined – Day

Griffon MFTA - PDA: Postural Sequence

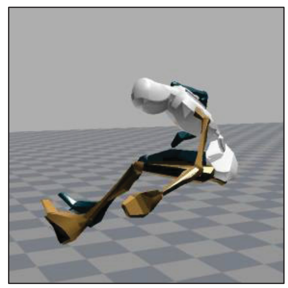
Postural Sequence:	Outside Scan Confined (NFP)
DAY	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
More scanning looks than #1 with more views to the side, back, and steeply down for landing position. More frequent scanning at night.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

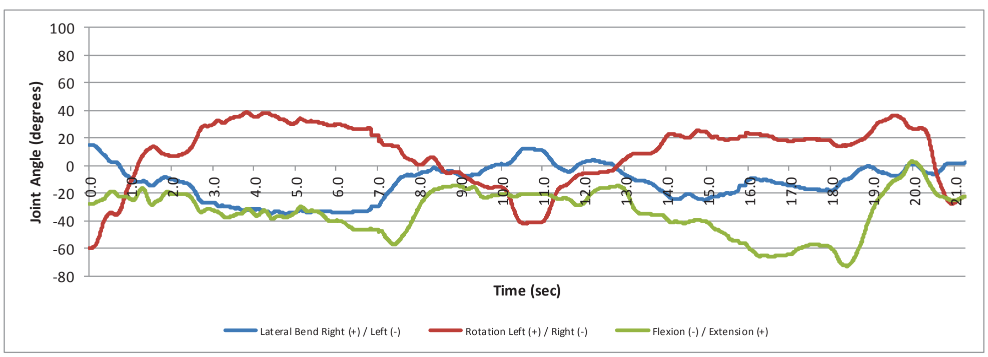
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	16.546	seconds

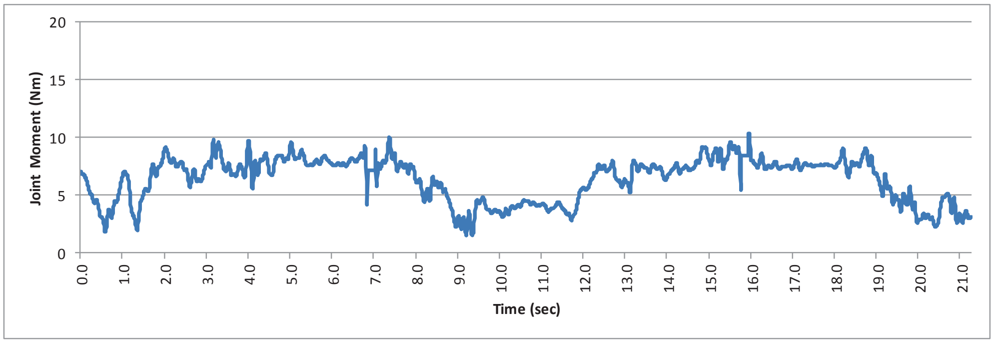
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	60.05	56.35	932.89
Tension (N)	NA	NA	NA
Anterior Shear (N)	13.22	4.89	33.44
Posterior Shear (N)	-22.13	-17.04	-165.61
Right Lateral Shear (N)	23.68	8.27	72.74
Left Lateral Shear (N)	-17.28	-4.78	-37.05
Torque (Resultant) (Nm)	6.27	4.82	68.34
Right Lateral Moment (+Mx) (Nm)	5.62	2.43	29.16
Left Lateral Moment (-Mx) (Nm)	-2.91	-1.11	-7.27
Left Axial Moment (+My) (Nm)	1.67	0.48	5.30
Right Axial Moment (-My) (Nm)	-1.69	-0.50	-2.80
Extension Moment (+Mz) (Nm)	5.98	4.04	66.92
Flexion Moment (-Mz) (Nm)	NA	NA	NA

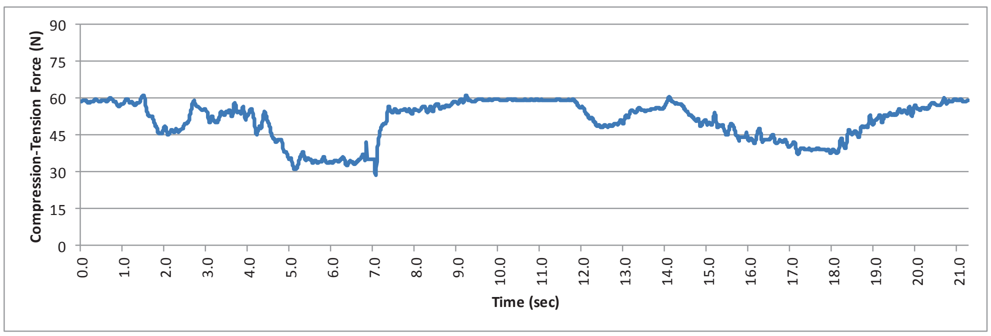
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	12.66	5.02
Left Lateral Bend	-20.75	-12.17
Left Axial Rotation	45.72	32.71
Right Axial Rotation	-36.99	-23.53
Extension	3.02	1.92
Flexion	-38.95	-23.14

Outside Scan Confined – Day

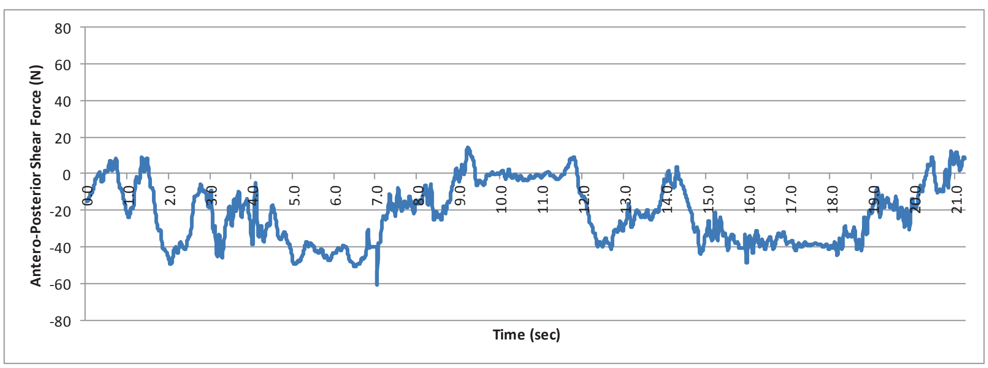
Resultant Neck Torque:



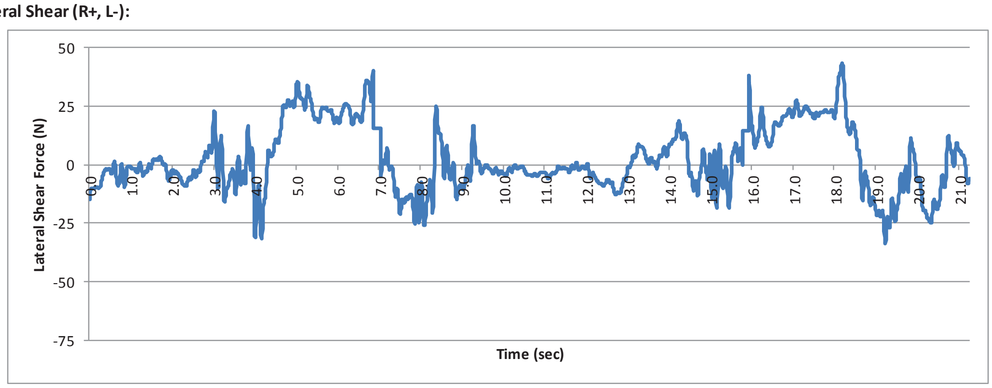
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



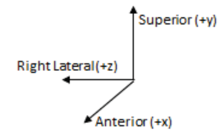
Lateral Shear (R+, L-):



Outside Scan Confined – Night

Griffon MFTA - PDA: Postural Sequence

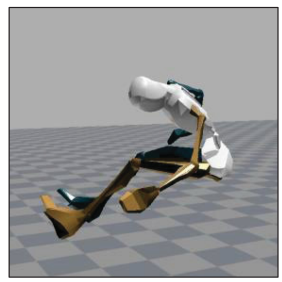
Postural Sequence:	Outside Scan Confined (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
More scanning looks than #1 with more views to the side, back, and steeply down for landing position. More frequent scanning at night.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

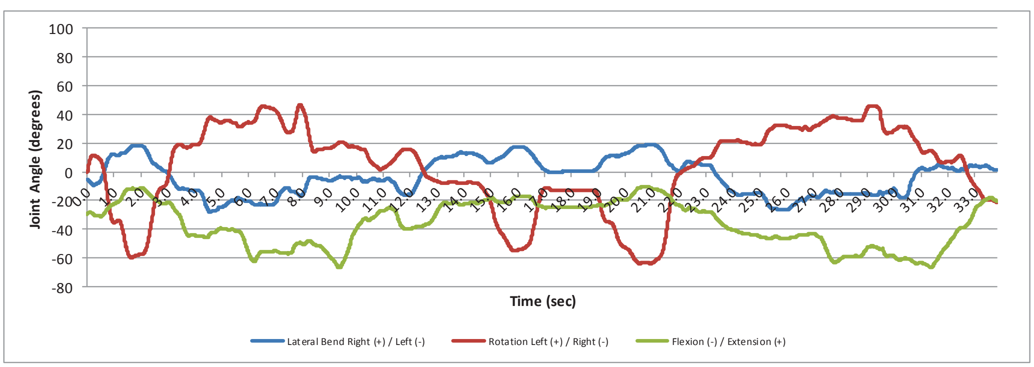
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



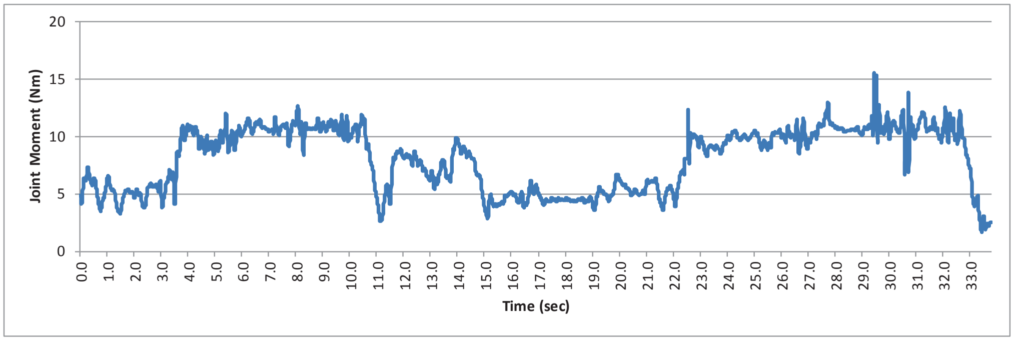
Posture Duration:	23.399	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Night):

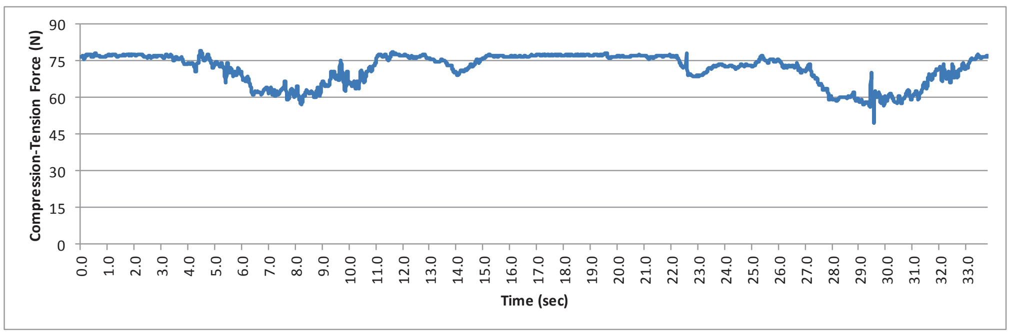
Force	Peak	Mean	Area	ROM	**Peak** (degrees)	**Mean** (degrees)
Compression (N)	78.51	73.11	1711.19	Right Lateral Bend	15.32	8.13
Tension (N)	NA	NA	NA	Left Lateral Bend	-25.08	-16.49
Anterior Shear (N)	19.21	6.55	72.63	Left Axial Rotation	57.32	36.93
Posterior Shear (N)	-40.55	-15.76	-291.01	Right Axial Rotation	-41.65	-24.99
Right Lateral Shear (N)	30.79	10.32	129.71	Extension	0.62	0.31
Left Lateral Shear (N)	-27.38	-6.50	-70.39	Flexion	-45.86	-25.92
Torque (Resultant) (Nm)	9.20	6.49	130.23			
Right Lateral Moment (+Mx) (Nm	7.76	3.49	67.17			
Left Lateral Moment (-Mx) (Nm)	-4.19	-1.67	-10.43			
Left Axial Moment (+My) (Nm)	2.34	0.65	6.75			
Right Axial Moment (-My) (Nm)	-2.78	-0.78	-10.17			
Extension Moment (+Mz) (Nm)	8.61	5.10	116.08			
Flexion Moment (-Mz) (Nm)	-1.64	-1.42	-2.68			

Outside Scan Confined – Night

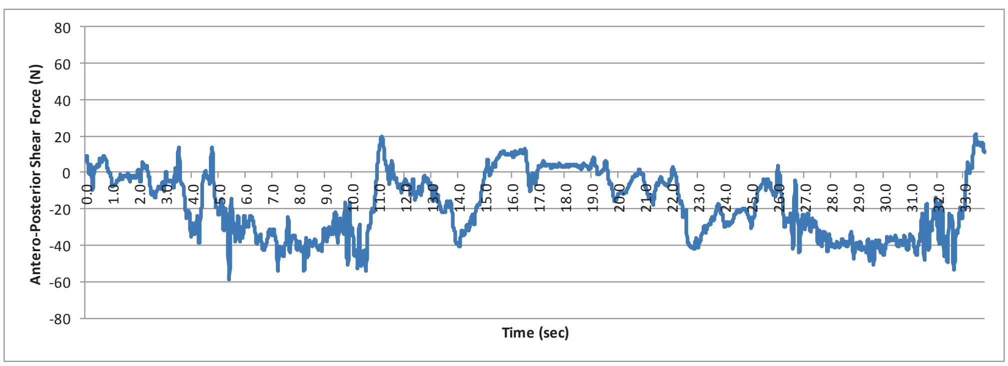
Resultant Neck Torque:



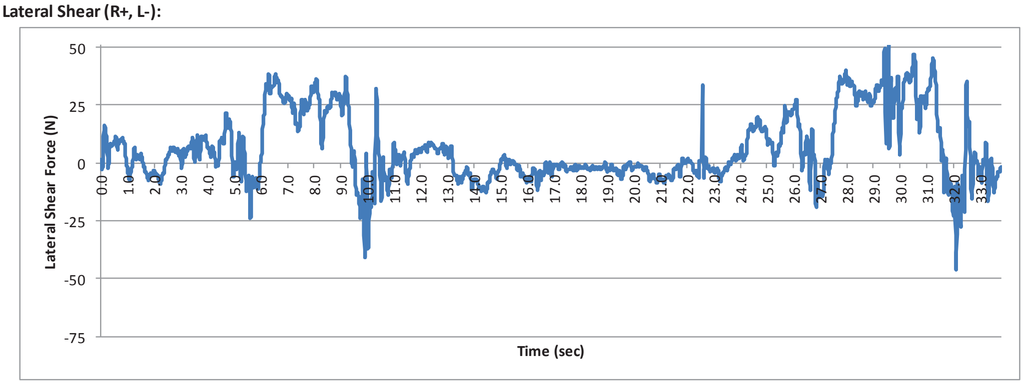
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



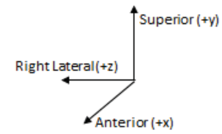
Lateral Shear (R+, L-):



Outside Scan Regular - Day

Griffon MFTA - PDA: Postural Sequence

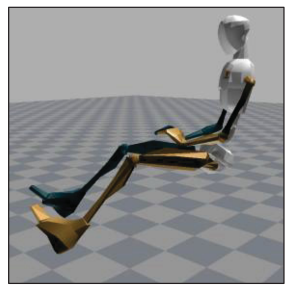
Postural Sequence:	Outside Scan Regular (NFP)
DAY	
Participant # (Sample Graphs):	NFP07
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
Observing through windscreen to the front and partially down and to the side. Night involves increased scanning due to lack of referents. (assumes not confined space)	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

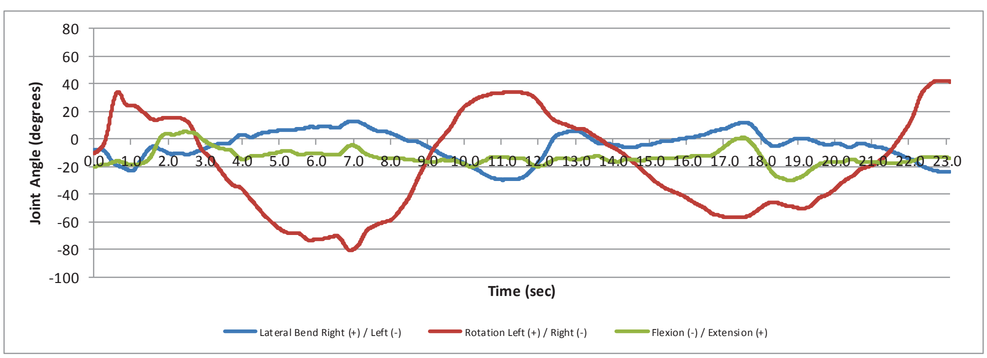
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	20.404	seconds

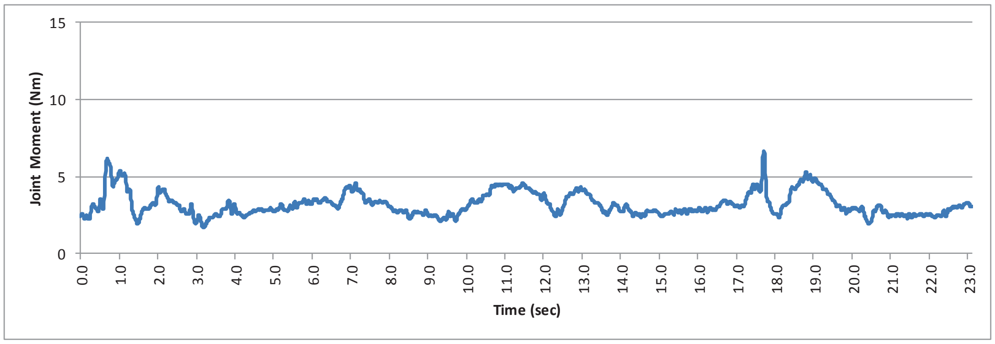
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	60.07	58.79	1200.02
Tension (N)	NA	NA	NA
Anterior Shear (N)	10.41	4.50	63.88
Posterior Shear (N)	-11.99	-6.07	-45.30
Right Lateral Shear (N)	6.40	3.52	9.19
Left Lateral Shear (N)	-12.15	-5.50	-97.89
Torque (Resultant) (Nm)	4.87	3.53	61.84
Right Lateral Moment (+Mx) (Nm)	3.29	1.32	10.95
Left Lateral Moment (-Mx) (Nm)	-3.28	-1.29	-15.71
Left Axial Moment (+My) (Nm)	0.95	0.31	5.57
Right Axial Moment (-My) (Nm)	-0.54	-0.18	-0.41
Extension Moment (+Mz) (Nm)	5.02	3.05	61.29
Flexion Moment (-Mz) (Nm)	-1.68	-1.08	-1.02

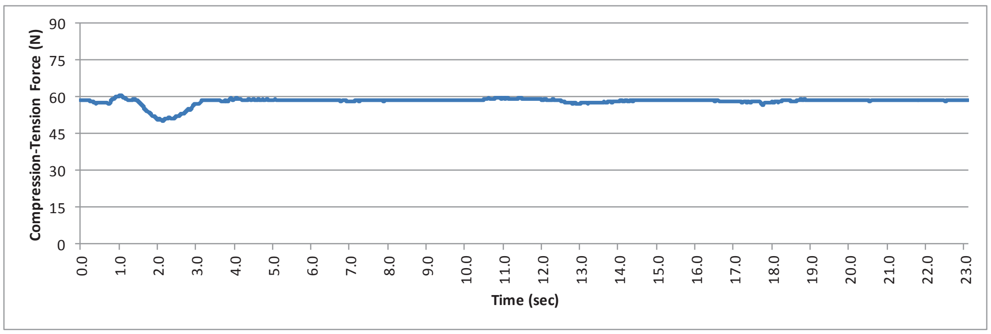
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	12.67	5.98
Left Lateral Bend	-18.34	-7.13
Left Axial Rotation	40.17	25.70
Right Axial Rotation	-47.85	-25.90
Extension	6.68	4.21
Flexion	-32.58	-20.42

Outside Scan Regular - Day

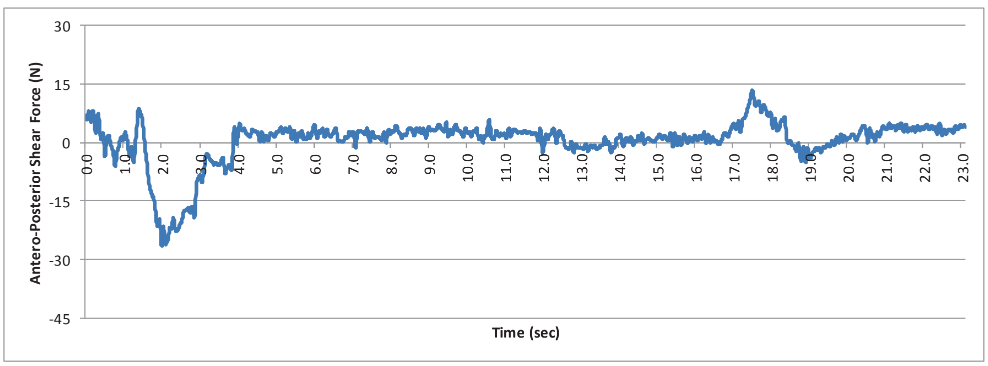
Resultant Neck Torque:



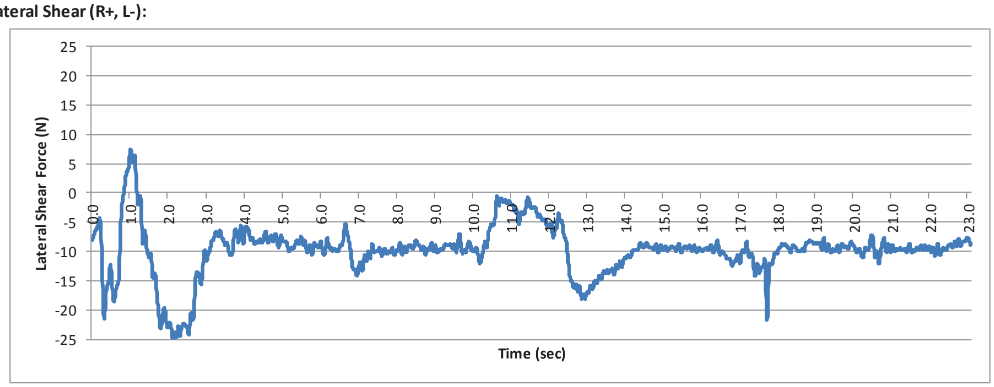
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



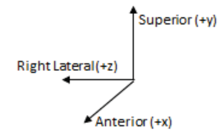
Lateral Shear (R+, L-):



Outside Scan Regular - Night

Griffon MFTA - PDA: Postural Sequence

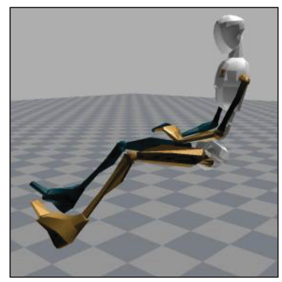
Postural Sequence:	Outside Scan Regular (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP07
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
Observing through windscreen to the front and partially down and to the side. Night involves increased scanning due to lack of referents. (assumes not confined space)	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

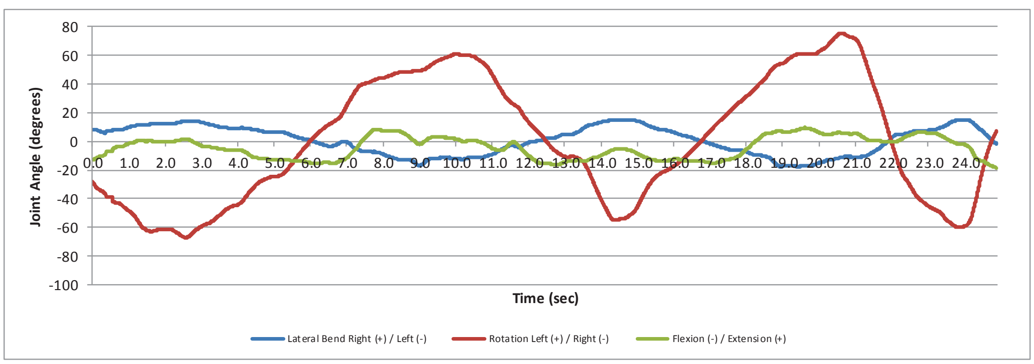
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	24.961	seconds

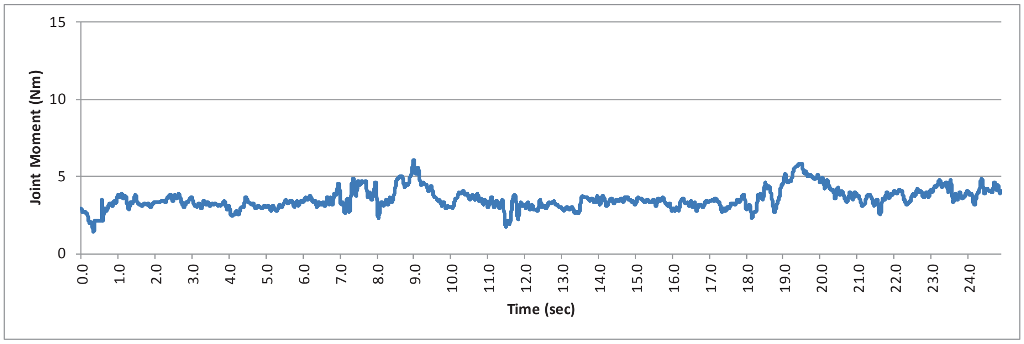
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	78.22	76.90	1920.20
Tension (N)	NA	NA	NA
Anterior Shear (N)	13.09	4.48	74.48
Posterior Shear (N)	-14.43	-6.03	-60.44
Right Lateral Shear (N)	11.67	3.46	23.22
Left Lateral Shear (N)	-13.09	-5.88	-120.50
Torque (Resultant) (Nm)	6.58	3.85	82.40
Right Lateral Moment (+Mx) (Nm	4.42	1.71	29.12
Left Lateral Moment (-Mx) (Nm)	-3.37	-1.99	-18.90
Left Axial Moment (+My) (Nm)	1.03	0.30	5.33
Right Axial Moment (-My) (Nm)	-1.01	-0.27	-1.91
Extension Moment (+Mz) (Nm)	5.96	3.07	73.71
Flexion Moment (-Mz) (Nm)	-1.13	-0.41	-0.57

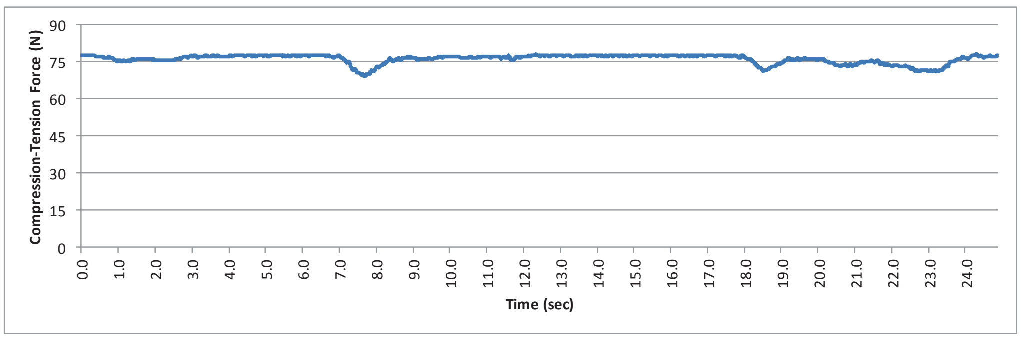
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	14.55	7.94
Left Lateral Bend	-18.91	-10.81
Left Axial Rotation	52.66	33.32
Right Axial Rotation	-42.45	-20.77
Extension	5.26	0.61
Flexion	-30.98	-17.77

Outside Scan Regular - Night

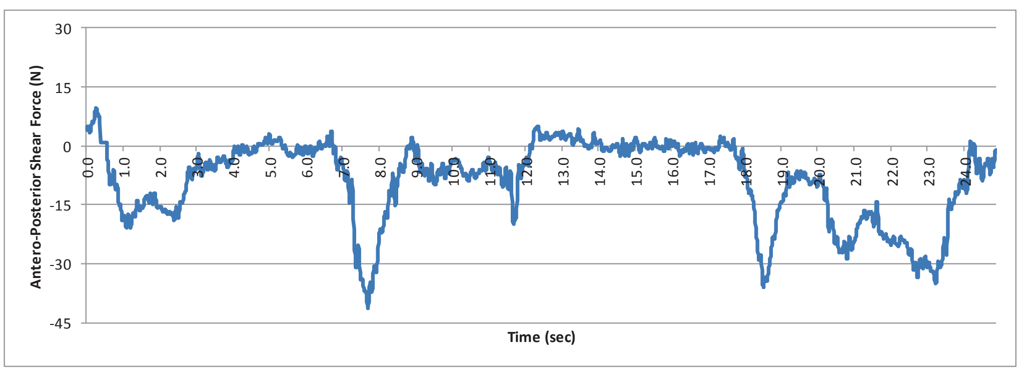
Resultant Neck Torque:



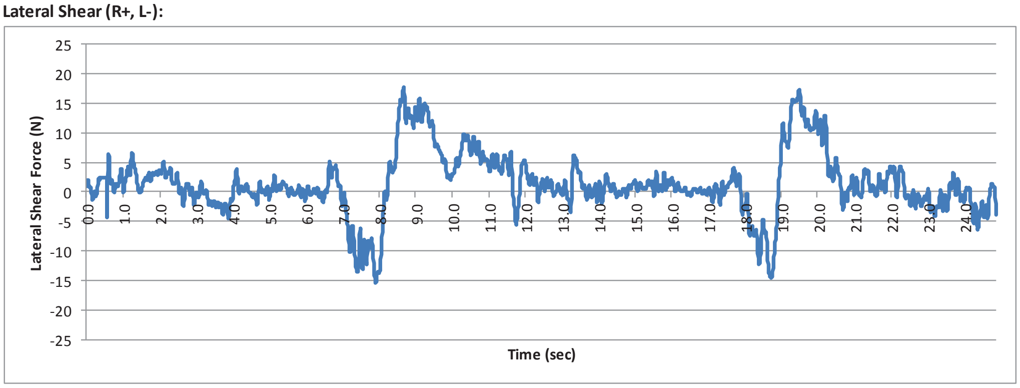
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



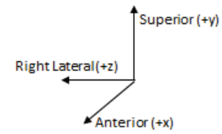
Lateral Shear (R+, L-):



Rapid Scanning - Day

Griffon MFTA - PDA: Postural Sequence

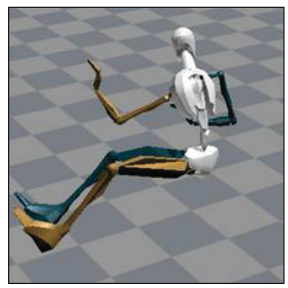
Postural Sequence:	Rapid Scanning (NFP)
DAY	
Participant # (Sample Graphs):	NFP07
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only



Task Description:	Equipment Considerations:
The NFP receives signal of or observes an immediate threat and rapidly scans to locate the threat.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

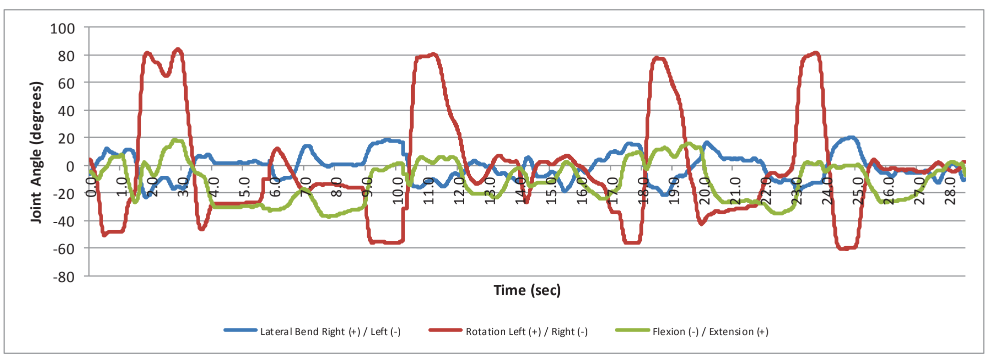
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	12.815	seconds

C7 Internal Joint Reaction Forces and Moments Summary (Day):

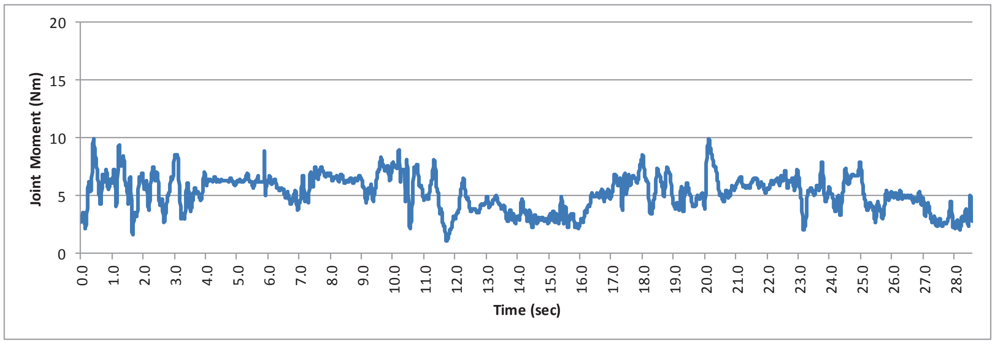
Force	Peak	Mean	Area
Compression (N)	60.63	53.82	690.14
Tension (N)	NA	NA	NA
Anterior Shear (N)	43.61	14.29	33.80
Posterior Shear (N)	-54.50	-19.84	-207.52
Right Lateral Shear (N)	33.65	9.90	35.14
Left Lateral Shear (N)	-35.34	-12.35	-114.50
Torque (Resultant) (Nm)	6.35	5.29	38.76
Right Lateral Moment (+Mx) (Nm)	5.35	2.22	13.20
Left Lateral Moment (-Mx) (Nm)	-5.50	-2.65	-18.19
Left Axial Moment (+My) (Nm)	2.01	0.63	4.14
Right Axial Moment (-My) (Nm)	-3.14	-0.94	-5.85
Extension Moment (+Mz) (Nm)	8.88	4.36	48.84
Flexion Moment (-Mz) (Nm)	-4.18	-1.19	-1.92

ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	16.72	8.92
Left Lateral Bend	-14.47	-12.41
Left Axial Rotation	58.22	55.31
Right Axial Rotation	-55.35	-37.75
Extension	17.33	7.12
Flexion	-32.76	-17.45

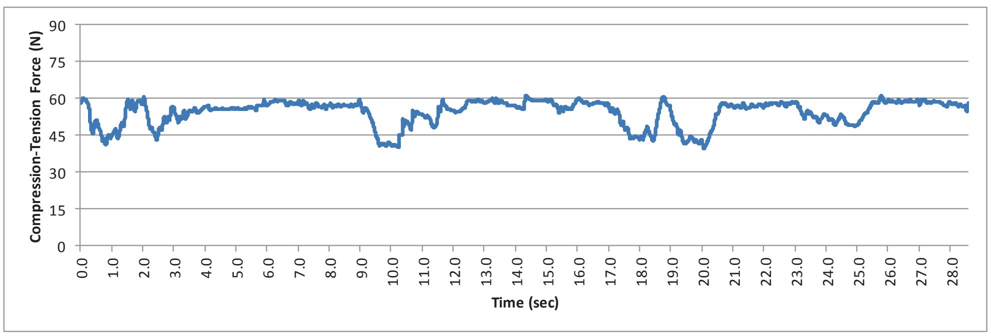
HUMANSYSTEMS Incorporated

Rapid Scanning - Day

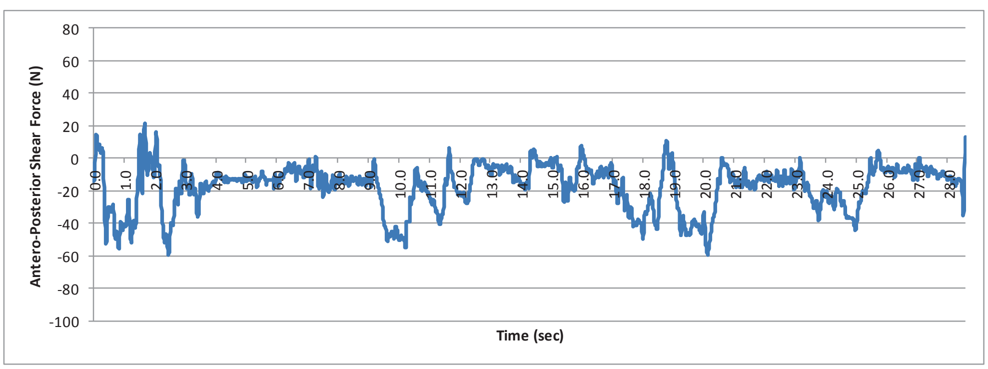
Resultant Neck Torque:



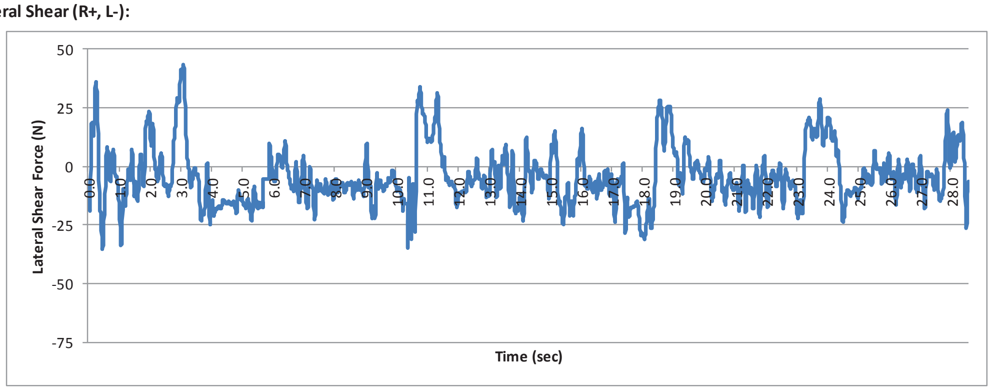
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



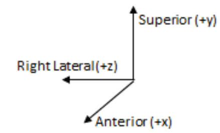
Lateral Shear (R+, L-):



Rapid Scanning - Night

Griffon MFTA - PDA: Postural Sequence

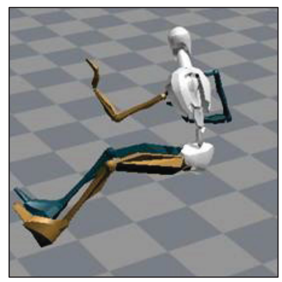
Postural Sequence:	Rapid Scanning (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP07
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	**Equipment Considerations:**
The NFP receives signal of or observes an immediate threat and rapidly scans to locate the threat.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

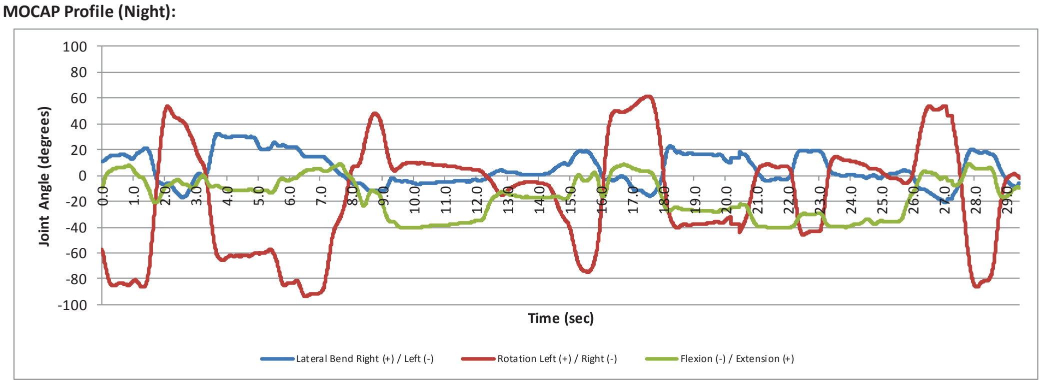
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	14.265	seconds

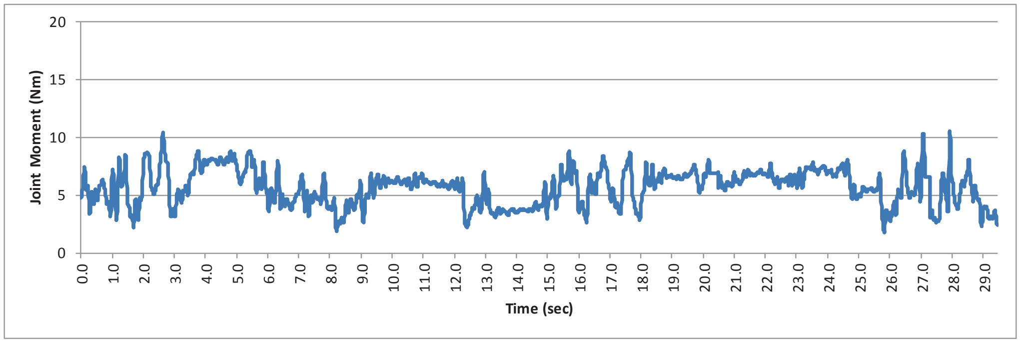
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	79.07	73.40	1047.58
Tension (N)	NA	NA	NA
Anterior Shear (N)	46.36	11.57	73.01
Posterior Shear (N)	-65.89	-23.01	-183.25
Right Lateral Shear (N)	31.83	9.10	35.96
Left Lateral Shear (N)	-37.42	-11.41	-117.80
Torque (Resultant) (Nm)	7.12	5.89	48.06
Right Lateral Moment (+Mx) (Nm	6.13	2.07	12.42
Left Lateral Moment (-Mx) (Nm)	-6.33	-2.96	-24.53
Left Axial Moment (+My) (Nm)	2.63	0.75	4.39
Right Axial Moment (-My) (Nm)	-3.80	-1.00	-8.34
Extension Moment (+Mz) (Nm)	10.80	4.39	59.24
Flexion Moment (-Mz) (Nm)	-2.61	-1.30	-0.99

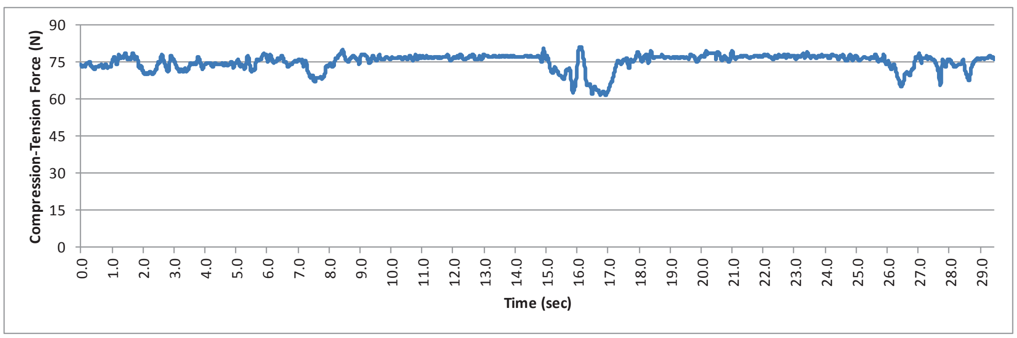
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	19.27	13.10
Left Lateral Bend	-22.87	-16.58
Left Axial Rotation	51.50	55.58
Right Axial Rotation	-71.25	-62.49
Extension	7.59	3.27
Flexion	-38.19	-18.73

Rapid Scanning - Night

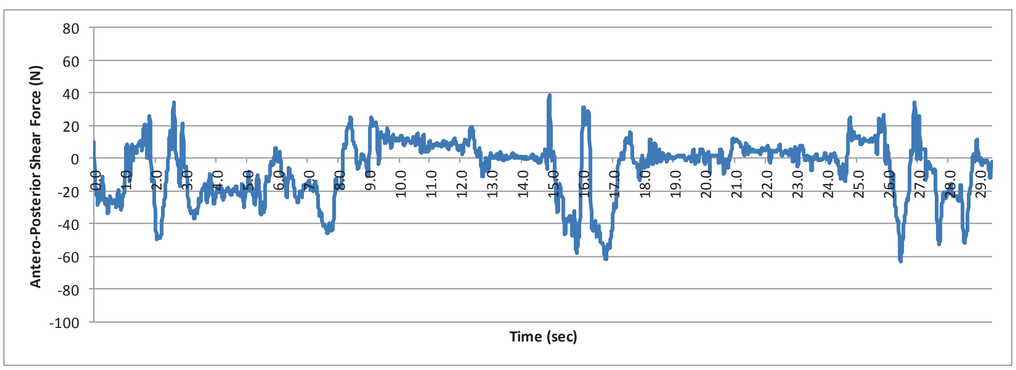
Resultant Neck Torque:



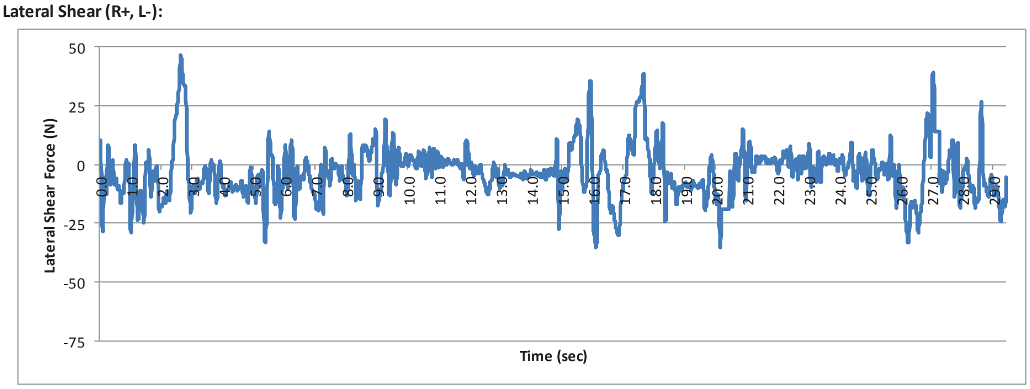
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



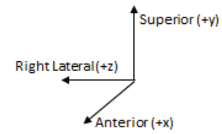
Lateral Shear (R+, L-):



Walking – Day

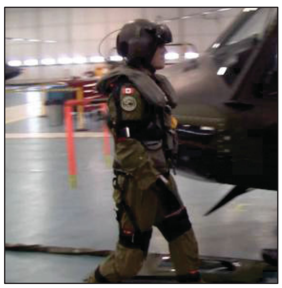
Griffon MFTA - PDA: Postural Sequence

Postural Sequence:	Walking (NFP)
DAY	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet Only

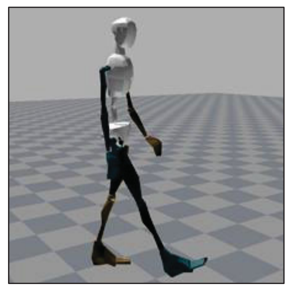


Task Description:	**Equipment Considerations:**
The NFP walks to the aircraft. At night, the NVGs may be lowered or raised.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

Image:

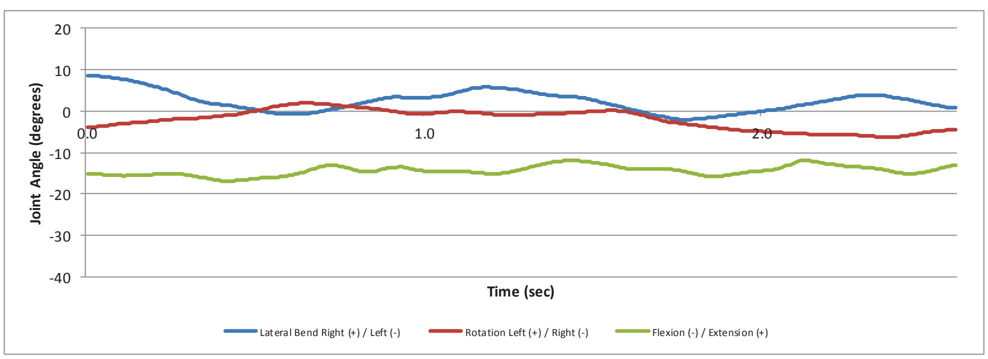


Photograph



MOCAP Screen Capture

MOCAP Profile (Day):



Posture Duration:	2.745	seconds

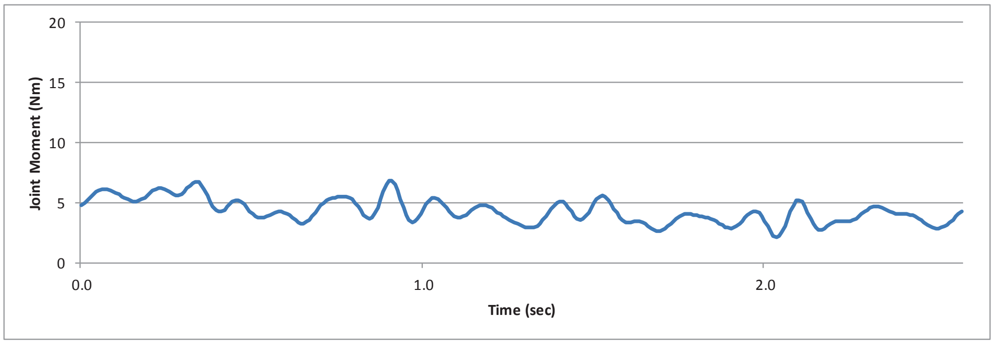
C7 Internal Joint Reaction Forces and Moments Summary (Day):

Force	Peak	Mean	Area
Compression (N)	64.88	58.73	161.70
Tension (N)	NA	NA	NA
Anterior Shear (N)	27.49	9.62	7.55
Posterior Shear (N)	-38.82	-12.72	-25.05
Right Lateral Shear (N)	22.03	6.14	8.68
Left Lateral Shear (N)	-23.11	-6.35	-8.51
Torque (Resultant) (Nm)	5.52	3.91	7.68
Right Lateral Moment (+Mx) (Nm)	2.40	0.81	0.83
Left Lateral Moment (-Mx) (Nm)	-3.68	-1.27	-2.19
Left Axial Moment (+My) (Nm)	1.06	0.28	0.30
Right Axial Moment (-My) (Nm)	-1.10	-0.31	-0.53
Extension Moment (+Mz) (Nm)	7.20	3.25	8.50
Flexion Moment (-Mz) (Nm)	-1.77	-0.83	-0.14

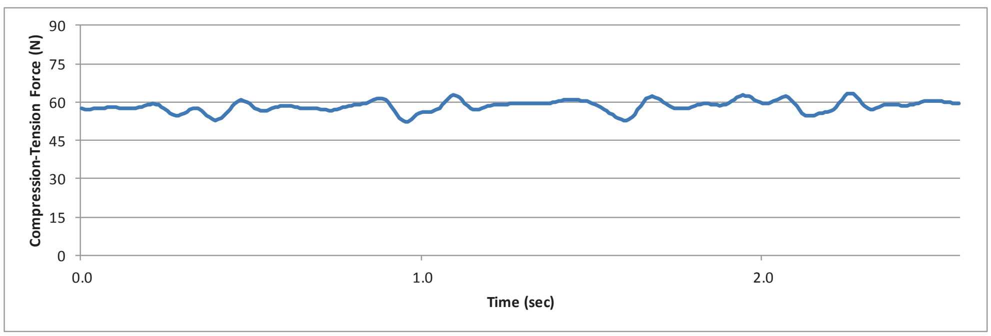
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	6.35	4.27
Left Lateral Bend	-2.65	-1.13
Left Axial Rotation	3.46	2.31
Right Axial Rotation	-12.02	-12.73
Extension	NA	NA
Flexion	-14.86	-12.06

Walking – Day

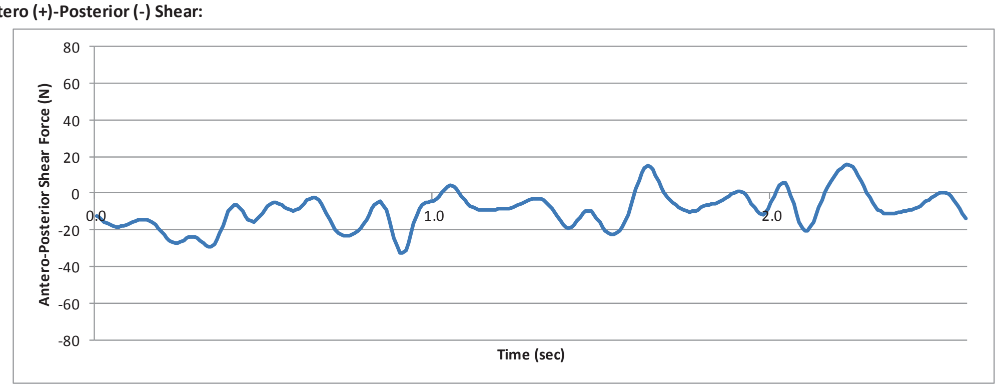
Resultant Neck Torque:



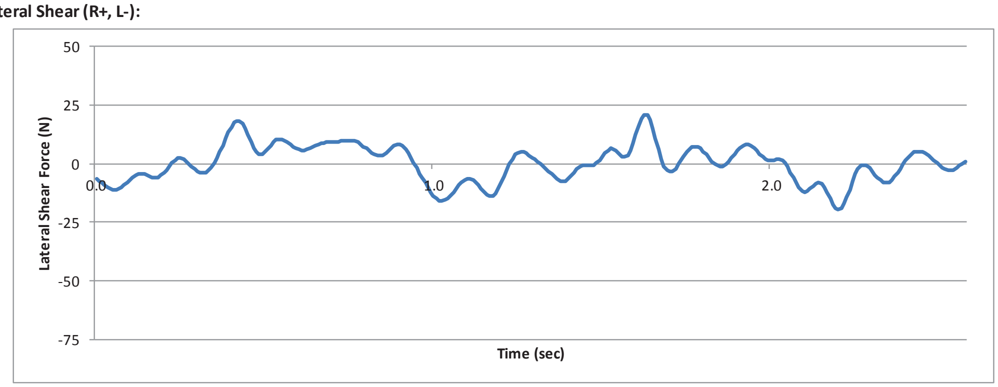
Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



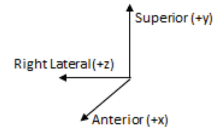
Lateral Shear (R+, L-):



Walking – Night

Griffon MFTA - PDA: Postural Sequence

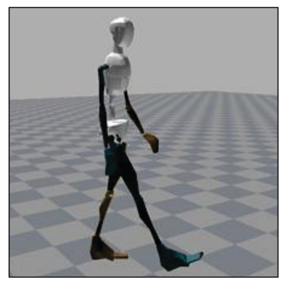
Postural Sequence:	Walking (NFP)
NIGHT	
Participant # (Sample Graphs):	NFP03
Role:	Non-Flying Pilot
Helmet Condition:	Helmet + NVG



Task Description:	Equipment Considerations:
The NFP walks to the aircraft. At night, the NVGs may be lowered or raised.	Helmet (HGY 56/P or SPH-5) Flight Suit Life Preserver and Safety Vest (LPSV)

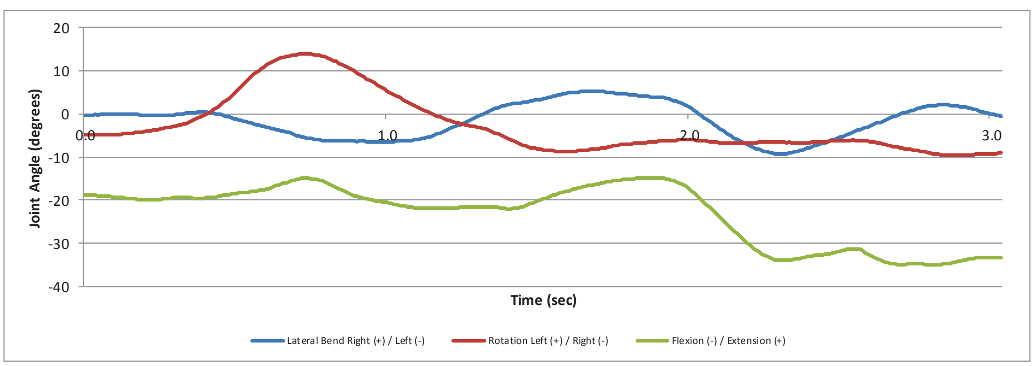
Image:

Photograph



MOCAP Screen Capture

MOCAP Profile (Night):



Posture Duration:	2.938	seconds

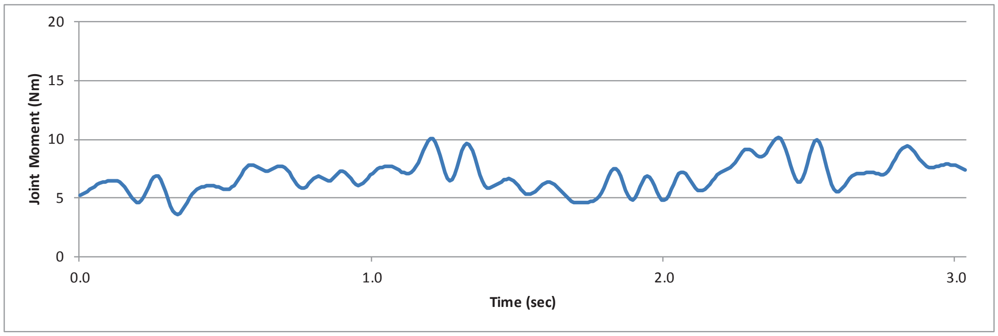
C7 Internal Joint Reaction Forces and Moments Summary (Night):

Force	Peak	Mean	Area
Compression (N)	84.11	75.36	221.99
Tension (N)	NA	NA	NA
Anterior Shear (N)	40.20	11.58	11.49
Posterior Shear (N)	-48.19	-14.24	-27.83
Right Lateral Shear (N)	29.58	8.92	13.32
Left Lateral Shear (N)	-29.13	-8.04	-11.68
Torque (Resultant) (Nm)	8.91	5.24	13.23
Right Lateral Moment (+Mx) (Nm	3.68	1.28	1.57
Left Lateral Moment (-Mx) (Nm)	-4.50	-1.47	-2.52
Left Axial Moment (+My) (Nm)	1.47	0.42	0.56
Right Axial Moment (-My) (Nm)	-1.33	-0.41	-0.66
Extension Moment (+Mz) (Nm)	10.13	4.42	12.18
Flexion Moment (-Mz) (Nm)	-3.10	-1.45	-0.33

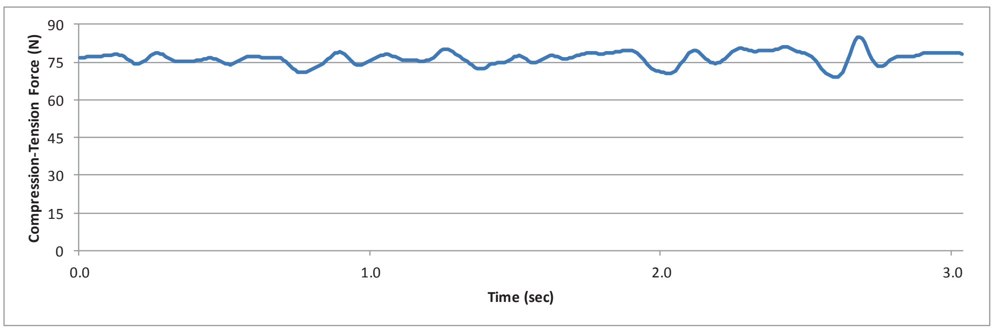
ROM	Peak (degrees)	Mean (degrees)
Right Lateral Bend	5.56	3.22
Left Lateral Bend	-6.80	-2.42
Left Axial Rotation	8.54	4.80
Right Axial Rotation	-13.15	-13.47
Extension	NA	NA
Flexion	-18.68	-14.78

Walking – Night

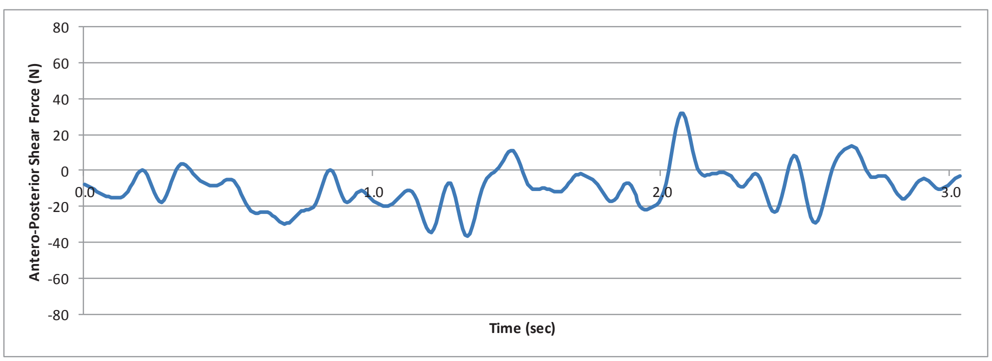
Resultant Neck Torque:



Compression(+)-Tension(-):



Antero (+)-Posterior (-) Shear:



Lateral Shear (R+, L-):